Summary Report to SCFGLC Cropland Livestock Integration on Carter Pasture with Mullis Livestock

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Executive Summary

This report touches on the integration of livestock into cropland through the grazing of cover crops using the adaptive multi-paddock (AMP) grazing technique. An additional aspect to this report is a discussion of the mechanism of contract grazing where cattle belonging to Mr. Kenny Mullis (Blythewood, SC) were brought to land operated by Mr. Jason Carter (Eastover, SC). A land rental agreement was entered into by both parties, and this can be seen in Appendix 3.

The land (or Carter Pasture) is a 20.45-acre parcel that has been row cropped since 2019; the entire field is mapped as a Norfolk loamy sand. Mr. Carter began operating the field in 2018 and planted soybeans, corn and soybeans in rotation, and cereal rye from 2018 to 2021; where no cash crops were growing, multispecies cover crops were grown. Before Mr. Carter took over the land's operation, it was a horse pasture in a degraded state.

Prior to bringing livestock onto the property, permanent infrastructure, namely, perimeter fence of woven wire, an internal midline fence of two strands of high tensile wire and a reliable multi-point water supply needed to be installed. Other considerations in the design for the summer months included ensuring access to shade and the necessity of cutting lanes with a bush hog to facilitate setup of mobile polywire fencing.

There were two distinctive grazing events. The first occurred from 3/24 to 5/8/2022 where 16 stockers grazed a multispecies cool season (cover) forage crop. The second event occurred between 7/6 and 10/3/2022 where 33 stockers, two brood cows and a cull cow grazed a multispecies warm season cover crop. In the first event (cool season forage or cover crop), 1.36 Animal Unit Months (AUMs) per acre were achieved and the stockers average daily gain was 1.85 lbs. In the second event (warm season forage or cover crop), 3 AUMs per acre were achieved but average daily gain for stockers was 0.44 lbs. The cool season forage crop performed poorly as a result of a dry fall that resulted in a poor stand dominated by cereal rye, which began to put on seed heads in mid-April. Disappointing livestock weight gain in the summer may be attributable to hot conditions, the presence of flies, and a forage crop that rapidly matured from mid-July. Retrospectively both cases, bringing livestock to the pasture 2-3 weeks earlier may have improved forage and livestock performance, however, had weather been unfavorable causing forage production to slow down, the risks of running out of forage in the early stages of grazing would have increased.

Forage plantings corresponding to the above grazing events were as follows:

- In October 2021, a cool season forage of cereal rye, black oats, flax, turnips, forage collard, radish, African cabbage, vetch and crimson clover was planted with a no-till grain drill at a rate of 40 lb./ac.
- On May 3, the westernmost 8 acres of the pasture was seeded in hybrid pearl millet at 27 lb./acre using a spin spreader. On May 21, a multispecies forage crop (sorghum sudangrass, sunn hemp, soybeans, sunflower and buckwheat) was drilled at a rate of 40 lb./ac into the eastern half of the pasture and on a 30 ft swath (one grain drill width) on the western side of the middle divide.

Forage inventories were conducted beginning in March and continued until the end of September 2022. The highest average forage biomass dry matter (DM) measured for the cool season forage crop was 2150 lb./ac (with a range of 480 lb./ac. of just-grazed forage and a high of 5200 lb./ac) on March 24, 2022. The warm season forage crop peaked on August 3 where an average DM biomass of 10,936 lb./ac (range 4598 lb./ac to 38,896 lb./ac) was measured.

Because a great deal of trampling of the summer forage was observed, eight samples of residue were taken from the field, and these measured at an average of 6,333 lb./ac (range was 4,215 lb./ac to 7,546 lb./ac) DM. While the trampling of forage may be considered "waste", it may also be seen as soil armor that was gently massaged into the soil by hoof action. In June, with the emergence of the warm season cover, a plant species count was taken, and the following species were observed roughly in order of abundance: millet, sorghum

sudangrass, crimson clover, sunn hemp, soybean, common bermudagrass and some coastal, johnsongrass, buckwheat, amaranth, dewberry, sunflower, pop clover, curly dock, crabgrass, flax and other species).

The Carter Pasture is conveniently flat (as are most other row crop acres in the Southeastern coastal plain) and measures some 1,250 x 740 ft. in the form of a regular rectangle. Apart from the perimeter fence, an internal fence of two strands of high tensile wire bisects the field along its 1,250 ft length creating two halves of 1,250 x 370 ft each, which can then be subdivided into smaller paddocks. After a short (3-day) settling in period, paddocks of 50 x 370 ft (or 0.4 acres) were created with the poly wire, one side on the energize perimeter fence, the other connected the internal fence bisecting the two halves. By the end of the second grazing event, the design had changed to 100 ft x 185 ft, these paddocks were still 0.4 ac in size. The 0.4 acre paddock size appeared to be a good compromise for both grazing periods, the resulting 50 paddocks allowed a once-a-day move kept livestock on 2% of the land at any time, allowing the remaining 98% to rest and recover. This was strictly true in the first event during the cool season where a (mobile polywire) back fence was kept. During the summer, the back fence was removed to allow animals access to shade – on the hottest days, cattle were in the shade from 8:30 am until after 6 pm.

It must be pointed out that the use of poly wire with the AMP grazing system, the livestock need to (1) learn to trust the human who provides the pasture and (2) learn to respect the electric fence. To achieve trust of the livestock, it was found that if the pastoralist spent a good part of the first three days with the cattle, enough trust was built up to be able to move the animals with little to no effort. To achieve respect for the fence, it is recommended that the perimeter fence be energized from the beginning, and once the animals have settled down in the forage around the water and mineral feeder, an electric poly wire fence can be introduced, first in a large area, and then in progressively smaller areas, to the point that the animals are used to the fence, and the fact that they will regularly be moved to fresh forage. It is important to make sure the fence is well energized, and our observations were that once a few adventurous steers touched their noses to the fence, the reminder of the herd learned to stay clear of the fence. Within a week of each event, the cattle were used to Mr. Carter, and upon hearing his vehicle would be waiting to be moved to fresh pasture.

For this pasture, approximately $17,000 were spent on infrastructure and establishing a forage base. These costs were higher than they needed to be because of circumstance related to weather and landowner time. Recurring costs in the first event amounted to $2,863 and revenues from the livestock owner for land rental and cattle weight gain were $2,055 amounting to a gross margin of -$808. Recurring costs for the second event amounted to $3,302 and revenues were $3,370 amounting to a gross margin of $68. If this case were repeated without any intelligent adjustments, a way to find a payback for infrastructure and forage base establishment would be challenging. However, much was learned from the first year and we anticipate improved performance in subsequent years. The economic benefit of soil health is difficult to quantify, even in an experimental situation, however, proxies for soil health in the form of soil tests are in place where a baseline sample set was taken in the fall of 2021 and spring of 2022; because we received sponsorship from the USDA-NRCS for this project in October 2022, soil testing will continue for another 2-3 years. Given that parts of this field will still be farmed, increases on income from row crops, grown with low inputs because of improved soil health, are anticipated.

Benefits in terms of live weight gain to the livestock owner are simple to calculate, however other benefits (e.g., rest for existing pastures, less labor, less feeding of hay, and improved animal health) are more difficult to quantify as these may be site-specific and very much dependent on weather and how much hay the livestock owner would need to feed. At best these benefits to the livestock owner are difficult to quantify, however there is a sense that Mr. Mullis benefited from this arrangement, even after paying Mr. Carter $5,575 for land rental and a share of the weight gain.

Introduction

This report touches on the integration of livestock into cropland through the grazing of cover crops using the adaptive multi-paddock (AMP) grazing technique. An additional aspect to this report is a discussion of the mechanism of contract grazing where cattle belonging to Mr. Kenny Mullis (Blythewood, SC) were brought to land operated by Mr. Jason Carter (Eastover, SC). There were two distinctive grazing events, the first occurred between 3/24 and 5/8/2022 where 16 stockers grazed a multispecies cool season (cover) forage crop, and the second event occurred between 7/6 and 11/3/2022 where 33 stockers, two brood cows and a cull cow grazed a multispecies warm season cover crop.

The intention of the landowner, Mr. Carter, was to test whether the use of livestock in intensive (in this case multipaddock adaptive) grazing management can accelerate soil health. When Mr. Mullis, the livestock owner, heard about Mr. Carter's intention, he was willing to participate in the project. Mr. Mullis is also a board member of the South Carolina Forage and Grazing Lands Coalition (SCFGLC).

This report is written through the eyes of someone who, prior to March 2022, had little or no direct experience with livestock management. The intended audience includes both landowner and livestock owner and we hope that the potential benefits of contract grazing can be communicated in this report.

While this report is laid out in a format of how 2022 unfolded in this story, it must be borne in mind that each situation is different in terms of the goals of the land- and livestock owners, location and condition of the land, location of the livestock relative to the land, and the type of relationship between land- and livestock owners. In this sense, we hope that this serves as an example to others of how some of these methods served to integrate livestock back into the land.

Finally, it must be noted that the story has only begun. For example, no row-crops have been grown on the land since 2019; this changed in the fall of 2022 where 25% of the pasture was planted in oats. Future plans include planting a portion of the land in corn, and then working with the livestock owner to graze corn stalks.

We are extremely grateful to the South Carolina Forage and Grazing Lands Coalition for their financial and other support in this project: this report would not have been possible without the SCFGLC's generous support.

Site Description

The 20.45-acre Carter Pasture (Figure 1) is located off 1840 St Matthews Church Road in Richland County, SC, at 33°53'59.7"N 80°43'53.1"W, FSA ID = Farm 3288, Tract# 10459 CLU #'s 17,24 and 29. The entire field is mapped as a Norfolk loamy sand.

Figure 1: Carter Pasture showing Mosaic of Aerial Imagery taken on August 12th. Note Grazing Paddocks (Cells) in the Northeastern Part of the Pasture of approximately 100 ft x 180 ft (~4/10th of an acre), and note Three Water Points (Water N, Water C, Water S).

Infrastructure

In Spring 2022, the pasture was fenced in with the perimeter fence being electrified while poly wire, step in posts and three reels were purchased for interior cattle movement. The field is approximately 1200 ft long by 740 ft wide and is bisected by a 2-strand high tensile wire fence. Note that a water point is also located at the shed on the southeastern side of the pasture, this is also where the well is located. Overall design and design changes will be discussed later in this report.

Permanent Fence

About half the perimeter of the field needed re-fencing. We used woven wire on the perimeter and included a single strand of high tensile wire that ran through pigtails approximately 2ft off the ground and 5" to the inside of the fence posts (Figure 2). The high tensile wire was electrified. There are two reasons for the high tensile wire addition namely (1) an electrically charged perimeter wire discourages livestock from rubbing themselves on the perimeter fence thus preserving the structural integrity of the perimeter – a must for low-stress animal management and (2) the high tensile wire on the perimeter provides an anchor point and power supply for the mobile poly wire.

Shade in the Summer

Note that for the second event (7/6 – 11/3/2022) it was essential to provide the livestock with access to shade which was only available along the south fence where trees line the edge of the field (Figure 1). This meant that in the summer, we were not able to make use of a mobile back-fence. During July and into mid-August, we observed the animals grazing before dawn and returning to shade as early as 8:30 in the morning, and then returning to pasture after 5:30 in the evening. The return to pasture was often initiated because we were moving them at between 5:30 and 6:30 in the evening.

Water Supply

A subsurface water line runs from the well next to the shed and along the bisecting fence (Figure 3a) to supply three water points (Figure 3b) that use a quick coupling for hose connection.

In the spring, a half 50-gallon drum with a Jobe valve and 150 ft of flexible hose (Figure 4a) was all that was required for 16 head. In the summer, a larger (~220 gallon) water tank was provided (Figure 4b). It was evident after a few days' use that the small tank, while providing sufficient water, was unsuitable because (1) any interruption of water supply would offer no buffer capacity for the herd and (2) the flexible hose would heat the water feeding to the tanks; the larger tank, because of its greater capacity, would not heat up to the extent that the small tank would.

Mowing Lanes in the Summer

While this is not strictly an infrastructure item, it bears mentioning that during the summer, we used a 5ft rotary mower (Figure 5) to mow lanes that allowed us to string poly wire. This is apparent in Figures 7, 12b, and 13. A 5 ft swath was often not enough (e.g., Figure 7) and we often needed to clear lodged sunn hemp and sorghum-sudangrass from the polywire in the morning – this situation was exacerbated after a heavy rain. Mowing was not necessary for the cool season forages.

Figure 2: Perimeter fence of Woven Wire with Pigtail Extending 5" out from Post, approximately 24" off the ground.

Figure 3: Subsurface water line that runs from the well next to the shed and then along the bisecting fence (3a) to supply three water points (3b).

Figure 4: Portable Livestock Watering Facilities: In Figure 4a (left) a half 50 Gallon Drum with a Jobe valve connected to a flexible Hose was adequate for 16 Stockers in the First Event. In the second event, this larger (~220 gallon) tank (4b) was required to ensure an adequate and somewhat cool Water Supply to the Livestock.

Figure 5: Mowing Lanes into Forage.

Field History

Prior to 2018 when the field was bought by the new owner, the field was a horse pasture. Based on observations at the time the field was purchased, the field was degraded with mostly a bermudagrass and

bahaiagrass cover, some crabgrass and a stand of johnsongrass in the southwestern corner. Prior to the first soybean crop in 2018, Mr. Carter planted a cool season cover crop to prepare the soil for the new cash crop. Cropping history for the field is shown in Table 1.

Table 1: Cropping History of Carter Pasture since May 2018.

Approximate Date Range	Plant Cover	Grazed?
Pre-2018	Degraded horse pasture	Y
May 18-October 2018	Soybeans	N
November 18 -April 2019	Cool Season Cover Crop	N
April – September 2019	Corn	N
October 19-May 2020	Cool Season Cover Crop	N
May 20-October 2020	Soybeans	N
October 20-May 2021	Cereal Rye (not harvested due to frost spoilage)	N
May-October 2021	Warm Season Cover Crop	N
October 21-May 22	Cool Season Forage Crop	Y
May-October 2022	Warm Season Forage Crop	Y

Livestock Events

In 2022, there were two event periods.

The first event was from March 24 through May 8, 2022 (57 days) where 16 stockers grazed a cool season cover crop (discussion of species to follow); the animals were removed with approximately 4-5 days of forage remaining. A bull calf was born in April to a heifer – this was unplanned. Of note in this period was that the dominant forage species was rye which began to head out in mid-April; by early May, the dry rye stalks were essentially ignored by the livestock and as such were no longer considered viable forage.

The second event began on July 6 where 2 brood cows and eight stockers (10 head) arrived, followed on July 7 by a cull cow and another 10 stockers (11 head), July 10 by another 4 stockers and then on July 10 by another 10 stockers, totaling 35 head. One heifer calf and one bull calf were born on August 3rd and on August 29th, respectively. On September 29, the two brood cows, the cull cow and the two calves (5 head) were removed and on September 15, 24 stockers were removed. Eight stockers remained from September 15 until they were removed on October 3.

Salient summary stocking calculations for each of the events are presented in Tables 2 and 3. Note that calculations for the first event (3/24 - 8/8/2022) are straightforward arithmetic, while those for the second, more complex event were calculated by spreadsheet.

Table 2: Livestock Numbers, Event Days and Weight gain for Each Event

Event Dates	No. of Animals	Total Days of Event	Animal-Days	Weight In (lbs)	Weight Out (lbs)	Weight gain (lbs)	Est. Gain Per Day/Animal
3/24 - 5/8/2022	16	57	912	13,786	15,480	1,694	1.85
7/6 – 11/3/2022	35	90	2,348	24,480	25,520	1,040	0.44

Table 3: Calculations of Animal Unit Months per acre. Basis: 1 animal unit = 1,000 lbs, one month = 30 days and acreage was calculated at 20.45 acres.

Event Dates	No. of Animals	Total Days of Event	Mean Stocking Density (lb/ac)	Animal-Unit Days	Animal Unit Months	Animal Unit Months per Acre
3/24 -5/8/2022	16	57	36,500	834	27.8	1.36
7/6 – 11/3/2022	35	90	62,500	2,202	73.4	3.0

Pasture Lease or Contract Grazing Agreement

Since the arrangement is between Mr. Carter (landowner/operator) and Mr. Mullis (livestock owner) a Pasture Lease or Contract Grazing agreement is useful to ensure both parties enter into the venture where false assumptions and misunderstandings are reduced to minimum. The Pasture Lease – Contract Grazing Agreement in Appendix 3 is what Mr. Mullis and Mr. Carter agreed to. Elements of the agreement included basic elements like the parties involved, the land description, computation and rates of charges and payments (with example calculations), duties of the livestock owner, duties of the landowner, right of entry to pasture and arbitration.

There are many boiler plate agreements of this sort available, and it was later pointed out to us that the agreement would need to include losses, what percentage of livestock loss (numbers or percent of weight) would be borne by the livestock owner and what losses would be assumed by the landowner.

In 2022, three calves were born in the pasture and, while the birth of a calf in April did not place much of a burden on the landowner, the two calves born in the summer did cause concerns and substantially more work. The newborns were often in the pasture and would not know or be too weak to return to their mothers who had walked back to shade. This meant that in the first few weeks of their lives, the landowner needed to search for the calves and move them back to shade to prevent them from overheating. We recommend that, for the summer season at least, a clause in the agreement ensure that there are only steers or that heifers are guaranteed open, at least, the agreement ought to cover the birth of calves whether this is intentional or unintentional, since newborn calves can add stress and complexity to this sort of grazing operation.

The agreement does not substitute for a good working relationship between landowner and livestock owner.

Notes on Livestock Handling Essential to Multi-paddock Grazing

The livestock that were received from Mr. Mullis, while tame, were not used to the electric poly wire fence and in addition, needed to become accustomed to a new set of strange humans. Once the animals were offloaded, they were allowed to roam the perimeter and generally explore the property. The water and mineral feeder were placed at a starting location and after some time, the animals gravitated to this location in the pasture. Initially, a poly wire fence was set up to confine the animals in a 350 ft x 370 ft area (roughly 3 acres) and then the fence was incrementally moved down to the 0.4-acre paddock size. More time was spent with the livestock in the first 3 days primarily to gain their trust and to observe their habits. Within three days, the animals learned to respect the fence and to trust the new humans to the point that they could be moved with little effort to a new paddock.

Gaining the trust of the livestock and teaching them to respect the fence allowed the herder to move them quickly, quietly and with no help. This is one of the foundations of low stress livestock management.

The pasture design and changes of design over time will be discussed in a subsequent section of that name.

2022 Forage Plantings

Cool Season Forage Plantings

In October 2021, a **cool season forage** of cereal rye, black oats, flax, turnips, forage collard, radish, African cabbage, vetch and crimson clover was planted with a grain drill at a rate of 40 lb./ac. The fall of 2022 was particularly dry, and the stand that was established was poor; the dominant species in February 2022 was cereal rye and much of this growth was attributed to volunteer rye from the failed rye crop grown between October 2020 and May 2021.

Warm Season Forage Plantings

On May 3, the westernmost 8 acres of the pasture was seeded in **hybrid pearl millet** at 27 lb./acre using a spin spreader.

On May 21, a **multispecies forage crop** was drilled at a rate of 40 lb./ac into the eastern half of the pasture and on a 30 ft swath (one grain drill width) on the western side of the middle divide. The multispecies forage crop was made of sorghum sudangrass, sunn hemp, soybeans, sunflower and buckwheat. Rainfall in between May 3 and June 13 totaled roughly 1.25 inches, and forage growth was initially slow, but with good rains from mid-June forage inventories increased rapidly.

Forage Inventory Methods

The forage inventory methods evolved over time. In the first event (3/24 - 5/8/2022), we took forage inventories on 8 occasions (Table 4). In an attempt to attain better confidence of the forage inventory, the number of samples increased over time. A $4ft^2$ quadrat made out of PVC was randomly placed in each sample location. Plants inside of the quadrant were cut, bagged and taken to the laboratory to be weighed fresh. They were then placed for 24 hours in a vented oven at 70 degrees C to dry and were weighed again. These forage details are available upon request.

In the second event, we refined our method to take three random samples in eight forage zones (Figure 6), providing a total of 24 samples. A $1ft^2$ PVC quadrat was used for this occasion, and ideally the quadrat was thrown in a random direction. The size of the quadrat was reduced because sample sizes for even $1ft^2$ became difficult to handle. At some point, we were also not able to throw the quadrat randomly over the forage because it was too tall, we estimate the sunn hemp and sorghum sudan were up to 13 ft – Figure 3 illustrates this point. At this stage, we took one edge off the quadrat and selected what we deemed a "typical" square foot and harvested from there – it is worth noting that ordinary shears were also useless and as the plants matured (Figure 7), a machete and garden shears were used to cut the mature, woody stalks. As per the cool season protocol, the samples were bagged and taken to the laboratory to be weighed fresh, then placed for 24 hours in a vented oven at 70 degrees C to dry and then reweighed. These forage details are available upon request.

In an attempt to capture some of the visual changes as a result of forage and changes in season we began to take images of each of the eight control points (Figure 11) – an example of a time sequence at Control Point 2

In mid- to late June, as the warm season forage began growing, we identified a number of plant species in the field, and with the forage inventory taken on 6/17, the samples were returned to the laboratory and prior to weighing, separated by (approximate) species and weighed. To ascertain diversity, individual plant species were picked in the field and brought back to the laboratory for identification (if not identified in the field) and for weighing. Identified species and estimated weights are shown in Table 4.

It bears repeating that by mid-July 2022, it became apparent that we would need to bush-hog lanes (Figures 5 and 7) for the poly wire fence in the forage to (1) avoid grounding out the poly wire, but also (2) to make the poly wire visible to the animals.

Figure 6: Carter Pasture showing Forage zones, fixed sample points (SP-PA-01 to 08), Water Points and Power Poles overlaid on Aerial Imagery taken June 17, 2022.

Figure 7: Graduate Student, Joe Montoya in Forage Zone 2 on August 3. At this point, the cover had not yet been grazed for the summer.

Forage Inventory Results

Forage Quantity

For the first event where cool season species (cereal rye, black oats, flax, turnips, forage collard, radish, African cabbage, vetch and crimson clover) were grazed, the mean forage inventory only exceeded 2000 lbs./acre on one occasion (Figure 8). We believe this was attributable to the poor stand density (Figure 9) that resulted from the dry fall of 2021.

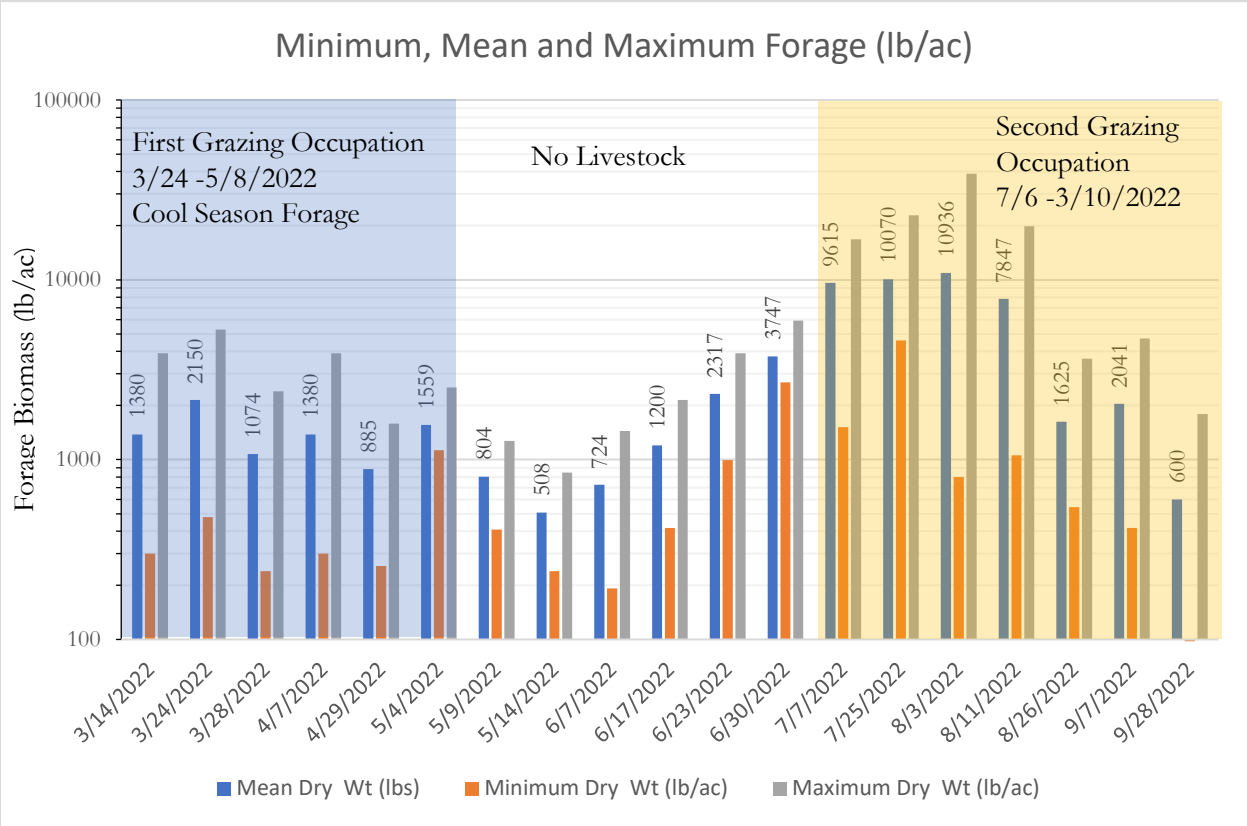

Figure 8: Forage Inventory for Carter Farms from 3/14/2022 to 9/28/2022, First and Second (Spring and Summer) Grazing Events and the Period with No Livestock are also shown. Data Labels are for mean (Average Forage (lb/ac). For the sake of presentation, the Y-axis is in log Format.

As forage dominated by cereal rye began to dry down and the warm season cover had not emerged, biomass dropped to a mean of 508 lb/ac on 5/14/2022, thereafter biomass increased steadily and, once rains came toward the end of June, biomass production increased exponentially even as livestock (35 head) were introduced in July (Figure 8). By mid-August, as forage matured and with grazing of 35 head, forage inventories began to drop. Some of the values in late September were also influenced by stalk cutting with a rotary mower which was intended for seedbed preparation and also to reduce the probability of weed seed (mainly sicklepod) maturation.

With the use of the grain drill on May 21 to plant the warm season cover crop, stand density issues were alleviated on the eastern side of the pasture and part of the western half of the pasture (30 ft to the west of the center line). Stand density was somewhat poorer in the western side of the pasture where only hybrid pearl millet was spread. Figure 10 illustrates the differences in stand density between grain drilled cover crop and the spread pearl millet.

Figure 9: Aerial Image taken on April 14, 2022, from 50 m showing appreciable amounts of Space between plants in the ungrazed Paddock (top right hand). Note the grazed paddocks (bottom of image) and even Manure Distribution.

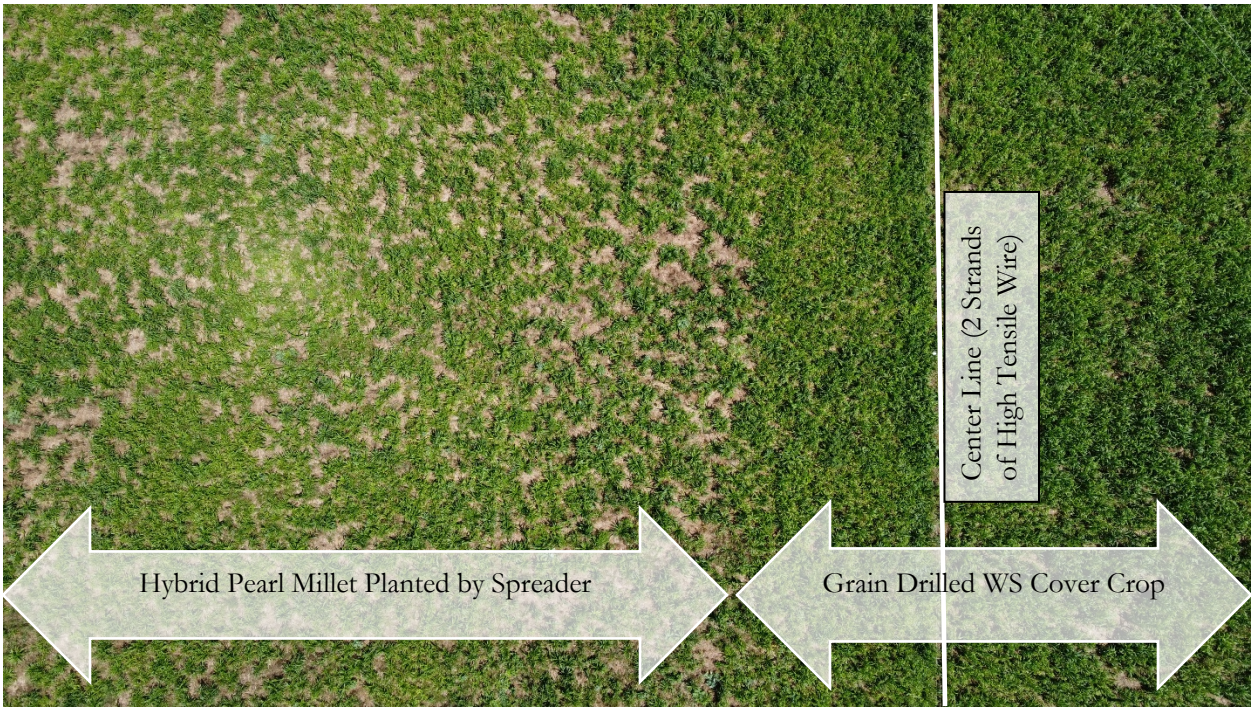

Figure 10: Aerial Image taken on July 7, 2022, from 50 m showing the Center Line, where the Seed spreader was used to plant Pearl Millet (May 3) and where the Grain Drill was used to plant the warm Season Cover Crop.

Forage Diversity

Only one attempt was made in June to deliberately quantify some of the forage species (Table 4) on the assumption that "everything is food" at some stage in the lives of plants.

Table 4: Inventory of Plant Species Found in Pasture circa 6/17/2022

Common Name	**Scientific Name**	**Percentage Forage**
Millet	*Pennisetum glaucum*	50%
Sorghum sudangrass	*Sorghum drummondii*	30%
Crimson Clover	*Trifolium incarnatum*	3%
Sunn Hemp	*Crotalaria juncea*	3%
Bermuda Grass	*Cynodon dactylon*	3%
Johnsongrass	*Sorghum halepense*	3%
Buckwheat	*Fagopyrum esculentum*	2%
Amaranth	*Amaranthus sp.*	<1%
Dewberry/blackberry	*Rubus caesius*	<1%
Sunflower	*Helianthus annuus*	<1%
Pop Clover	*Trifolium nanum*	<1%
Curly Dock	*Rumex crispus*	<1%
Crab Grass	*Digitaria sanguinalis*	<1%
Flax	*Linum usitatissimum*	<1%
Other		<1%

A reasonable idea of change in forage quality and quantity over time can also be shown in the ground control point images (Figure 11) at Control Point 2 (SP-PA-02 in Figure 6). On 4/21, when we first took these images, the cereal rye was already beginning to show signs of maturation by 5/14 this process was almost complete. On 6/7, volunteer buckwheat was emerging. Just over a month later on 7/14, sorghum sudangrass and sunn hemp began to dominate as can be seen in 8/22 (note also the sickepod plant), at some point in August, we were no longer able to locate the control point flags (approximately 6 ft) for more images because the forage was so tall. Once Forage Zone 2 was grazed regrowth of the sorghum sudan was apparent as well as a new flush of volunteer buckwheat (9/7/2022) toward the middle of September, we also noted germination of the sorghum sudangrass (not shown in this image) where seed heads had fallen to the ground.

Figure 11: Sequence of Control Point Images for Control Point #2 (SP-PA-02 in Figure 6).

While the exercise of taking images at each control point was onerous, the images in Figure 11 do provide some insight into the evolution of the cool and warm season forages over the season and as a result of grazing.

Residue

Given some of the very low biomass weights after a grazing event, under ordinary circumstances, there is a legitimate concern regarding bare or exposed soil. However, the residue base in Figure 7 suggests very little soil exposure or bare soil. This was especially apparent in the summer when a large proportion of the mature plants were trampled to the ground - we subsequently found the term "trample grazing" would have been appropriate for this situation. On September 7, we selected one site in each grazing zone and collected residue only (no green plant material) using the 1ft² quadrat. The residue was taken to the laboratory and dried in a vented oven for 24 hours at 70 degrees C, the same as the biomass samples. We were surprised to see that the average residue mass was 6,333 lb/ac dry (average moisture was 24%), but since the 35 head of cattle had grazed in all places where we collected the sample, we think that the trample grazing contributed to

this number. Prior to the acquisition of cattle in early March 2022, we noted a good deal of residue already present from the previous warm and cool season covers (Table 1). While there was some exposed soil from cattle paths, especially in the summer where we needed to allow access to shade, this was a very small percentage of the field.

Table 5: Soil Cover, or Residue on Carter farm taken on September 7, 2022.

	Dry Residue Weight (lb/ac)
Forage Zone 1	7546
Forage Zone 2	4214
Forage Zone 3	6468
Forage Zone 4	7546
Forage Zone 5	7546
Forage Zone 6	7056
Forage Zone 7	4704
Forage Zone 8	5586

Livestock Movement – Design and Change of Design Over Project Progression

This exercise provided us with a hands-on lesson in design and design change over the project's progression as our own experience grew. The pasture design not only includes permanent infrastructure like perimeter fence, internal permanent fencing, and water, but it also needs to take into account the operator's goals, time and resource constraints and how much internal fencing is available[1].

The goal at the Carter Pasture was to do as much as possible to increase soil health, while ensuring at all times the health and welfare of the livestock. To this end, the animals were moved on a daily basis to ensure as long a rest and recovery for the forage as possible. Design evolved in roughly three phases, over the spring and summer grazing season.

Phase 1 Design (3/24 -5/8/2022)

After a settling in period in the first event (3/24 -5/8/2022), the 16 stockers were moved in paddocks that were 50 ft long and 370 ft wide (Figure 12a) with the use of three reels. One side of the poly wire was anchored to the perimeter fence and the other to the midline high tensile wire (Figure 3a, 12a). This created 48 pastures of roughly 0.4 acres each that theoretically facilitated a rotation where the cattle were on only 2% of the land at any time while the reminder of the land was resting for 48 days. A few adjustments were made to this initial design in response to realities on the ground. From a labor point of view, the operator was required to roll up 370 ft of poly wire and pick up 12-14 step in posts, reset the back fence and set up the next day's fence. While this exercise only took 11 minutes (along with moving the water) it did not seem optimal. In addition, with the very wide paddocks, the cattle tended to walk up and down the paddock, presumably looking for the best grazing. We experimented with tightening the livestock and moving them twice a day in 180 ft x 50 ft paddocks, but this required more labor. Toward the end of the first event, we moved the back fence and the water less frequently and noted that the stockers were always more interested in the newer forage, thus reducing the utility of a tight back fence. We understand this method is called "open gate" rotational grazing where, while livestock can move back to old forage, they generally will not if provided

[1] There is a joke that answers the question "how many reels do I need?" and the answer is "always one more".

with fresh forage. Approximate stocking density in this phase was 14,633lbs[2] in 0.4 acres or 36,500[3] lb/ac (or 36.5 AU/ac).

Phase 2 Design (7/14/2022-7/25/2022)

At this point we acquired two additional reels and 1250 ft of additional poly wire. We split the west half of the pasture into 120 ft x 100 ft paddocks, while paddock size and the squarer shape were suitable, this proved to be more labor intensive for several reasons.

Figure 12: Aerial Imagery from May 2022, showing 50 ft x 370 ft Paddock Outlines (Figure 8a) while Figure 8b is imagery taken on July 14 where the southwest corner of the paddock was divided into 9 paddocks roughly 1200 x 150 ft in size.

Phase 3 Design (7/25/2022-10/3/2022):

We used the newly acquired 1250 ft poly wire to divide either the west half or the east half (this depended on where the livestock was) longways into another two strips, each 180 ft wide. These were then divided every 100 ft to make 180 ft x 100 ft paddocks of 0.4 acres each (Figure 13). By bisecting one or the other half of the pasture, we needed posts every 100 yards[4] that were sturdier than the plastic step in posts. We used the structurally sturdy t-posts between the perimeter fence and the mid fence, insulated by old 2" PVC pipe, to anchor our reels and to provide us with assurance that the poly wire would hold (Figure 14). The 1250 ft

[2] Arithmetic average of live weight in and live weight out for the occupation (3/24 -5/8/2022),

[3] There were occasions where we tightened up the grazing to 0.15 acres or less, this we were able to achieve close to 100,000 lb/ac. The labor to achieve this with our system and forage base was prohibitive because it required us to move the livestock 2 to 3 times a day.

[4] Between the perimeter fence and the permanent high tensile wire in the center of the pasture.

center poly wire and the t-posts at each 100 ft formed a semi-permanent fence that allowed us to move animals with the poly wire reels for approximately 24 days (roughly 12 paddocks on each side) with very little additional labor. Once we move from the east side to the west side of the pasture (or vice versa), we needed about 3 hours to break down the bisecting poly line and t-posts and move them to the other side of the fence. Another advantage of this setup was that moving, and setup time was reduced to about 5 minutes since by this time, 185 ft of poly wire had to be rolled up and only 4 step-in posts were required. Paddock size remained at roughly 0.4 acres and average stocking density for the entire second event was approximately 62,500 lb/acre[5] (or 62.5 AUM/ac).

Figure 13: Carter Pasture with 180 ft x 100 ft (~0.4 acre) Paddocks.

[5] There were periods in good forage where we grazed on 0.2 acres, thus doubling the livestock density to 125,000 lbs/acre, but even though the calculated forage was sufficient, it became clear that this tight acreage with this tall forage (Figure 3) was too small.

Figure 14: T-Posts with a PVC Sleeve for insulation provided a more stable Anchor in the middle of the Field than step-in posts. While this set up would remain in place for roughly 24 days, it allowed us to anchor/rest the poly wire reels that were used to move the animals on a daily basis.

Next Steps

The USDA-NRCS has awarded a 3-year grant to U of SC's SoilHealthLab and SCFGLC entitled "Using Livestock Integration and Adaptive Multi-paddock Grazing to Enhance Soil Carbon Uptake and Improve Soil Health". The intention of the project is not to convert cropland back to pasture, rather, to work on how we integrate livestock into cropland and assess, forage, cash crop, livestock and soil health and how this affects landowner and livestock owner financially.

After the livestock were removed for the second grazing event, Mr. Carter planted 5 acres of oats[6] on 10/12/2022 intended for harvest in early June and for sale as organically grown since no chemicals have been used on the land since 2023. The intention is that some animals are turned into the oats wile they are in vegetative stage, with the idea of minimizing frost damage to the oats in the likely event of a late frost occurring. The remining 15 acres were seeded on 10/11/2022 with the mix (Table 6) with a 30' no-till Landoll grain drill.

Given that no burn-down was used, seeding rates were 2-3 times higher than what is typically used in a straight cover crop mix; the intention was to improve probability of a good stand where warm season grasses (Bermuda/bahaiagrass, crabgrass and johnsongrass) dominated. A combination of a good rain shower before

[6] Usaing a 30' no-till Landoll grain drill

planting followed by a cold snap, then another shower after planting appears to have facilitated a good stand of cool season forages without the benefit of a burn-down herbicide pass (Figure 15).

Table 6: Forage Seed Mix Planted into 15 Acres of Carter Pasture on 10/11/2022.

	Rate (lb/ac)	% of Mix
Triticale "surge"	40	38%
Oats - Black	40	38%
Rape - dwarf Essex	3.33	3%
Turnips - appin	1.665	2%
Turnips - barkant	1.665	2%
Vetch - woolypod raw	3.33	3%
Vetch - hariy - raw	3.33	3%
Forage collards-impact	6.66	6%
Clover - Dixie Crimson	3.33	3%
Clover - Ladino Regal Graze	1.665	2%
Clover - Durana White	1.665	2%
Total	**106.64**	**100%**

Figure 15: Day of planting Forage and then Subsequent Dates of Stand Progression

No decision has been made for the 2023 summer growing season, however, the likelihood of another cash crop being planted, even in small acreage, is high.

Money Matters - Landowner

Startup Costs – Infrastructure and Establishing a Forage Base

Before one can run livestock, it is imperative that one establishes adequate infrastructure and to ensure that a proper forage base is also established[7]. In the case of the Carter Pasture, there were startup costs for items like perimeter and interior permanent fence, water lines, trenching, hoses, electrical gear to power the mobile fence, step-in posts, poly wire, hardware fittings and seed to establish a good forage base. Our original intention was to begin grazing in the summer of 2021, but excess moisture and time constraints in 2020/21 meant that we established the perimeter fence in early 2022. Total startup costs for the 20-acre pasture were around $17,000. Whether this is typical or not depends on what infrastructure already exists. In addition, because grazing was deferred by one year because we were unable to establish the infrastructure in 2020/21, the cereal rye crop of 2020/21 and the summer cover crop of 2021 were not utilized, adding additional costs due to delay. The positive side of this is that we were able to establish a good forage base and even where the stands were thin because of a dry October 2021, a substantial residue base, or soil armor was established. While the benefits of the residue layer were not measured, a good residue base provides soil armor or protection that reducers raindrop impact and subsequent runoff/compaction, protects soil from direct sunlight and reduces soil temperature, this is especially important in the summer to reduce plant stress through high temperatures and low soil moistures. Because of time constraints, an outside contractor was hired to install the permanent fence (Figures 2 and 3a). Clearly these costs could have been lower if done in-house. However, this is a decision each landowner will have to make themselves and depends on the relative amounts of time and money is available to the landowner. Details of startup costs are shown in Appendix 2.

Recurring Costs and Revenues – First Event (3/24 - 5/8/2022)

See Table A2 in Appendix 2 for a detailed breakdown of expenses and revenues.

In this event, expenses included seed, grain drill operation, rent and electricity and a small amount ($300) of hired labor, which could be included in start-up or recurring costs. Note that nothing (not one dollar) was spent on herbicides, pesticides or any sort of fertilizer. Total expenses for the period were $2,863 (or $127 per acre). Revenues from rental and weight gain share (Tables 2, 3 and Table A2 in Appendix 2) amounted to $2,055 giving a gross margin of -$558.

While recurring expenses and inputs were low, we believe the biggest contributor to the loss were because of lower revenues for the following reasons:

1. In retrospect, the animals could have arrived 2-3 weeks earlier, but this may have been risky because of the poor forage stand.
2. Once the livestock arrived, forage was growing at a rate that they could not keep up with, therefore in theory, the land could have carried more head of cattle in the March 15- April 15 window.
3. Because the dominant species was cereal rye, the rye headed out and became unpalatable, leaving the cattle to pick out the oats and brassicas (forage collards and African Cabbage). By the first week of May it was apparent that the forage base was depleted, and the cattle were removed in a timely fashion – we estimated less than a week of good forage remained by the time the animals were removed. Were there a better stand of oats (which could have been the case if October 2021 were not as dry) we think the cool season grazing period would have been extended. In addition, we are experimenting with some forage ryegrass in the fall 2022 planting season. The ryegrass (3 bags) will

[7] We have seen too many cases where livestock are bought prior to the establishment of infrastructure and a forage base. The new livestock owner pays for this in time (e.g., hauling and feeding hay), money (e.g., purchasing hay and fixing water systems) and anxiety (e.g., looking for cows at 3 am on a Sunday morning).

be kept to only certain areas namely the extreme southern end of the field (mostly in shade in the summer) and the driveway access to the field (about 1.4 acres and not included in the field acreage). While the ryegrass will extend the spring grazing season, the landowner is wary of ryegrass because of its reputation (more specifically wild Italian ryegrass) of substantially interfering with wheat crops.

Given all of the unknown information in March 2022, making a loss of under $1,000 (or under $50 an acre) in the first grazing event, was considered a win.

Recurring Costs and Revenues – Second Event (7/25/2022-10/3/2022)

See Table A2 in Appendix 2 for a detailed breakdown of expenses and revenues.

In this event, while expenses included seed, grain drill operation, rent and electricity, unexpected costs were incurred because of the need for lane cutting and, later on, stalk chopping, the latter was conducted several times. In August, this was to stimulate regrowth of the grasses, and in October, stalk chopping was performed to prepare a good seed bed. In both cases sicklepod, which had been present on some of the field that had had less cover (poorer stand) was cut back in the chopping process, an added benefit. Use of the tractor(s) and bush hogs (JD1050 and JD3080) for these tasks added an additional $900 (or about 27%) to the summer cover expenses. Note that nothing (not one dollar) was spent on herbicides, pesticides or any sort of fertilizer. Total expenses for the period were $3,302 (or $161 per acre) and while revenues from rental and weight gain share (Tables 2, 3 and Table A3 in Appendix 2). Amounted to $3,370 giving a gross margin of $68.

We learned from the first event and requested more animals for the second event, which allowed us to earn $2,616 in rental over this period. There were two unexpected items that contributed to a lower grass margin, namely (1) the additional $900 in machine time for lane cutting and stalk chopping and (2) far lower than expected weight gains. Our initial hopes/calculations were that the 33 stockers would add 2 lb/day per stocker for about 70 days (July 6 to mid-or late September) the expected revenue from weight gain might have been 4,620 lb, roughly four times more than the 1,040 lb experienced. The $4,620 in weight gain would represent $3,350[8] (instead of $754). We attribute the low weight gain to the following factors: (1) heat – in the July to mid-August period, the cattle foraged mainly until 8:30-9am in the cool of the morning and after 5:30-6 pm. For the reminder of the time, they sought shade. (2) Flies – given that the animals spent a lot of the day in the shade, i.e., the same place, flies had an opportunity to breed and stay with the animals; were the animals able to stay on the move away from their own manure each day, fly pressure may have been lower. (3) Distance from shade to forage – as we moved the cattle from south to north (Figure 13) they had to spend more energy walking to and from forage to shade. One option to reduce these two effects may be to invest in portable shade, which is expensive and never as effective as shade trees. Nevertheless this is a consideration. (3) A third contributor to low weight gains may also be that because the livestock were introduced to the field just before the forage crop reached maturity, by the time the livestock had made it to the ungrazed forage in August, the forage was mature and not as nutritious. Steps to mitigate this may include (a.) introducing the livestock 2-3 weeks earlier and initially rotating the animals through the field quicker to benefit from the more tender forage, and to clip the forage and keep it in a vegetative state for longer. The faster rotation may mean reducing stocking density (i.e., giving more acreage to the herd before tightening up to 0.4 acres) but this would be limited in its effectiveness in the summer because of the need for the animals to travel back to shade.

While a $68 gross margin (or $3.32 per acre!) will make no-one wealthy, we did not lose money and we learned a great deal.

[8] 4,620 lbs.x $1.45/2= $3,349 where $1.45 was the market price for live beef per lb, since the weight gain was shared between livestock owner and landowner, the market price (or the weight gain is divided by 2).

Soil Health

As yet, this is an intangible since we only have baseline data, however we hope to see an increase in organic matter and an increase in microbial diversity[9]. While soil test measures are important proxies for soil function, the aim of the landowner is to see improved soil function namely better infiltration, improved nutrient recycling and lower weed pressure over time. These benefits for now are intangible.

Manpower and Labor

Apart from hired labor, all labor was done by Mr. Carter with occasional assistance from Dr. Kloot. The majority of the labor required was to move livestock and water and to break down and set fence up. Typically visits to move the animals took between 3 and 19 minutes a day. Often driving to the pasture took longer. In the second event, additional time was taken to set up every 24 days or so (removing and driving in t-posts and insulation pipes between mid-fence and perimeter and then resetting on the other side of the field). The setup typically took 2-3 hours initially, but as we were planning less on the fly, setup became a lot easier. In the first event, poly wire fence runs were 370 ft and used up 12-13 step in posts. Over the summer, because of the semi-permanent divides with the t-posts[10], poly wire runs were 185 ft with 4 posts, often requiring less than 3 minutes to move the cattle.

In the first event, we deployed automatic gates (https://teeterfarmtech.com/) to reduce labor, however we found that the labor to set up the gates again often offset the time saved. No automatic gates were deployed in the second event: our reasoning was that since we did not have a back fence, the livestock would not always be aware when the gates were open. Nevertheless, automatic gates do need to be tested to reduce trips to the field by the landowner, and we plan to use technology from Teeter Farm Tech and fence lifters from Pensagro©, a South American company.

While we have not put a dollar value on labor, estimates for time spent need to be accounted for. These include negotiating with livestock owner, initial setting up of fence, receiving animals from the livestock owner, and spending more time (2-3 days) to gain the trust of the animals. Field operations including planting of forage crops, stalk chopping and lane cutting (the latter two restricted to summer), routine trips to move the animals and the water, break down and set up of fences. Our rough estimates of these would be 20-30 minutes per day that would include travel time to the pasture. Weed eating around the permanent fencing also needs to be accounted for.

Money Matters – Livestock Owner

One benefit to the livestock owner from this exercise can b readily calculated, namely that of livestock weight gain. Other costs benefits can be estimated, keeping in mind that these will be dependent on the home pasture state, rainfall, location in relation to the contracted pasture (i.e., travel distance), and the livestock owner's stocking rate, to name a few. Other benefits, e.g., animal health, improved home pasture condition, soil health, are less tangible and measurable. Nevertheless, the following costs and benefits have been discussed in conversations with the livestock owner, Kenny Mullis.

Costs (listed in approximate order of most to least tangible)

Expenses to pay for rent and weight gain to Mr. Carter were $2,055 and $3,370 = $5,575.

Transportation costs: Running a trailer between Blythewood and Eastover (76 mile round trip) for roughly 10-12 head per load. The livestock owner also made site visits every few weeks from Blythewood to check in with the landowner and on the livestock.

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[9] We are using the phospholipid fatty acid (PLFA) soil test to look at the prevalence of bacteria, fungi (saprophytic and mycorrhizal) and protozoans (largely grazers and predators) in the field.

[10] In the future, 5' or 6' fiberglass posts will be considered to replace metal t-posts in the operation.

Miscellaneous: In this case, the livestock owner provided minerals and the mineral feeder[11] – this was a nominal expense but is worth noting.

Labor: Catching livestock at the livestock owner's – for Mr. Mullis's animals, this is somewhat routine, but there is labor involved. In addition, transporting and setting up temporary catch pens at the pasture was another cost borne by the livestock owner.

Benefits (listed in approximate order of most to least tangible)

In terms of weight gain share, the animals added 1694 lbs.in the first event and 1040 lbs.in the second event or a total of 2,734 lbs. The livestock owner is able to gain a premium from the market for his grass-fed beef (above $1.48/lb as of October 17, 2022). However, one may argue that these weight gains would have occurred had the animals stayed at Mr. Mullis's operation. If we use the market rates (as mentioned, much lower than what Mr. Mullis can fetch for his grass-fed beef) from Tables A2 and A3, minimum benefit to Mr. Mullis would be $1,143 +$754 = $1,897 in weight gains realized, after paying Mr. Carter for his half of the weight gain.

The following benefits are less tangible/concrete than the weight gain, again dependent on rainfall and condition of the livestock owner's pastures, nevertheless, these need to be considered in the discussion:

Reducing/eliminating hay costs: The most quantifiable benefit to the livestock owner would be the elimination or reduction of feeding hay. This benefit is very much dependent on the livestock owner's land, it's condition, stocking rate of livestock (e.g., cow-calf pairs that stay behind) and weather (temperature and rainfall) conditions.

A simplistic analysis is as follows:

Suppose the livestock owner had no additional forage, i.e., they needed to feed hay were the herd to stay on the home place (this was not the case for Mr. Mullis). If we assume that hay requirements are 2.5% of live weight and that hay feeding efficiency is 75%, maximum hay savings would be as follows:

First event: 14,633 lbs.[12] x 0.025 x / 0.75 = 487 lbs. per day or 27,802 lbs. for 57 days; at a price of $83[13]/1,000 lbs.= maximum hay savings would be $2,307.

Second event: 20,008 lbs.[14] x 0.025/0.75 = 666 lbs. per day or 59,357 lbs. for 89 days; at $83/1,000 lbs. bale, maximum hay savings would be $4,926.

For both events bought hay savings would total $2,307 and $4,926 = $7,233

Table 6 provides an insight into some of the livestock owner's cost savings that would depend on how forage is available at the livestock owner's land. In this case, a breakeven for the livestock owner is if his land could provide 75% of the forage demand, anything under the 75% appears to be a benefit to the livestock owner.

Table 7: Scenarios for benefits to the Livestock Owner for sending them to Carter Pasture.

Scenario	**Hay Purchase**	**Market Value of Weight gain**	**Hay Purchase**	**Less $3,528 in Rental to**

[11] Important to note in the agreement whether the landowner or livestock owner provides the mineral feeder.
[12] Weight in-weight out divided by 2.
[13] Based on Clemson/Georgia Extension hay Budgets are $87.24 for hybrid bermudgrass hay and $79.46 for fescue hay.
[14] Average stocking rate over 89 days this accounts for the incremental increase in the number of head in the beginning and also the fact that eight stockers (5,000 lbs.) were left on the land from 9/15 to 10/3.

	Savings ($)	($) to Livestock Owner[15]	Savings and Weight Gain ($)	Landowner ($)[16]
No forage available – only hay fed	$7,233	$1,897	$9,130	$5,602
Forage base can supply 25% of feed Requirements	$5,424	$1,897	$7,312	$3,784
Forage base can supply 50% of feed Requirements	$3,616	$1,897	$ 5,513	$1,985
Forage base can supply 75% of feed Requirements	$1,808	$1,897	$3,705	$177
Forage base can supply 100% of feed Requirements	$0	$1,897	$1,897	-1,631

Table 6 does not account for hay hauling/shipping costs, on site labor to feed hay and cost to run equipment for feeding hay. These costs would be highly site specific (e.g., does the livestock owner producer their own hay, do they import it from far away or close by, how far do they need to move the hay to where the livestock are), but we know they would only add to the purchasing cost of hay.

Table 6 is not meant to provide a definitive answer, but it does point to the likelihood that the livestock owner stands to benefit from such a contract grazing relationship.

Other less tangible benefits include the following:

Animal Health: Anecdotal benefits (at least in this project) include reports from Mr. Mullis over the summer that his cow-calf herd, because they were able to utilize forage that would otherwise have been set aside for the stockers, were as healthy as he had ever seen them. In a conversation with Dr. Patty Sharko, extension/ field veterinarian from Clemson, we understand that in the late summer "slump" (i.e., forage growth stunted because of hot, dry weather) in late summer, livestock illnesses tend to increase. Apart from one case of pink-eye observed in one steer in October, no illnesses were observed in either of the grazing events.

Soil/pasture health: Allowing the livestock owner's land to rest longer would logically lead to improved pasture condition, and possibly better soil health as forages would be allowed more time to rest and recover. Quantification of this is outside the scope of this project, but would be an interesting, if not complicated exercise.

Conclusions

To the best of our knowledge, this combination of adaptive multipaddock grazing of annual multispecies forage (cover) crops combined with a contract grazing between landowner and livestock owner, is the first of its kind in this state. Given the many unknowns, accommodations and adaptations that the landowner and livestock owner needed to make, this exercise was a learning experience that was at worst, breakeven in terms of operating costs. At the time of this report being written (November 2022) soil health benefits or soil improvements (e.g., increase in organic matter) have not yet been quantified.

Revenues for the first and second grazing events (3/24-5/8/2022 and 7/6 -10/3/2022) were $2,055 and $3,370 for 57 days and 89 days respectively. Per day revenues for the landowner were $36/day and 37/day for the first and second grazing events, respectively. After expenses, gross margins were -$808 and $68, or -$14.17 and $0.76 per day for the first and second events, respectively.

[15] After paying landowner

[16] $912 and $2,616 for the first and second grazing events

What are the takeaways from this experience?

In the first event, while the animal gains (1.85 lb/animal/day) were encouraging, the limiting factor was that the stockers needed to be moved off the pasture after 57 days as the cool season forage matured. An earlier introduction to the pasture, a better stand and dominant forage species other than cereal rye could have prolonged the grazing event and may have contributed to better weight gains in the stockers. The planting of cool season forage on October 11, 2002, is likely to be more successful than the 2021 plantings; prior to and just after planting, we saw good rain showers, in addition, just after planting, a cold snap terminated many of the warm season plants that may compete with some of the cool season plants[17]. In addition, the grass basis for the forage is black oats which will be palatable at least a month after cereal rye has matured, finally, other species like forage collards, clover and vetch all appear to be growing well.

In the second event, we were able to graze 35 animals on 20 acres for almost three months, however, weight gains were disappointing at 0.44 lb/animal/day. Obvious contributors to low weight gains include the need for animals to return to shade at the southern end of the pasture each day, flies, and as the forages began to mature, low quality forage. Portable shade could be purchased, but at a cost, and arrangements would need to be made to have water move with the shade which may also be challenging. In terms of landowner stress the summer months proved more challenging, especially the concerns about adequate water and the welfare of the newborn calves and, when long distances needed to be walked from shade to fresh forage, the welfare of the cull cow.

In 2023, the project will continue under the sponsorship of the USDA-NRCS and we (landowner, livestock owner and UofSC) will try to find ways to improve the experience for all parties in terms animals and the growing of cash crops in between grazing events.

[17] No burndown herbicide was used, therefor a frost to eliminate competitors like crabgrass and bahaiagrass was timely.

Appendix 1: Forage Inventory by Zone

Table 8: Forage Inventory in lb/ac by Forage Zone (Figure 2) with Mean, Minimum and Maximum Values

	29-Apr	4-May	9-May	14-May	7-Jun	17-Jun	23-Jun	30-Jun	7-Jul	25-Jul	3-Aug	11-Aug	26-Aug	7-Sep	28-Sep
Zone 1	392	1441	760	240	416	736	992	3848	7066	8926	6315	2753	1184	4706	320
Zone 2	1000	1833	1272	688	448	416	1088	2684	12394	12019	21963	19847	3649	512	928
Zone 3	1585	2521	944	848	192	1216	2657	5940	10579	22851	38896	15814	1248	416	1793
Zone 4	672	1240	536	680	288	768	3905	2881	13430	11674	5154	1056	1120	4386	64
Zone 5	696	1128	960	696	768	2145	3713	3239	3752	7583	800	4289	992	608	160
Zone 6	1232	1441	704	352	1216	704	1441	2884	1516	7833	7281	9027	544	672	896
Zone 7	256	1465	848	296	1024	1985	2657	4819	11362	4598	2689	4257	2689	3809	128
Zone 8	1248	1400	408	264	1441	1633	2081	3678	16823	5076	4387	5730	1569	1216	512
Mean lb/ac	885	1559	804	508	724	1200	2317	3747	9615	10070	10936	7847	1625	2041	600
Maximum (lb/ac)	1585	2521	1272	848	1441	2145	3905	5940	16823	22851	38896	19847	3649	4706	1793
Minimum (lb/ac)	256	1128	408	240	192	416	992	2684	1516	4598	800	1056	544	416	64

Appendix 2: Cost and Revenue Details

Table A1: Startup/Initial and Capital Costs

Timing	Qty	Unit	Description	Unit price	Sum
Fall 2020	27	tons	Chicken Litter	$25	$675
Fall 2020	27	tons	Spreader for Litter	$12	$324
Fall 2021	20	acres	Grain Drill Rye	$30	$600
Fall 2021	20	acres	Rye Seed	$14	$280
Summer 2021	20	acres	Plant Summer Cover	$30	$600
Summer 2021	20	acres	Summer Cover Seed	$25	$500
Fall 2021	20	acres	Roll Summer Cover	$12	$240
Fall 2021	20	acres	Plant Cool Season Forage	$30	$600
Fall 2021	20	acres	Cool Season Forage Seed	$20	$400
Spring 2022	2000	ft	Perimeter fence	$5	$9,000
Spring 2022	1	Each	High tensile wire interior	$650	$650
Spring 2022	1	each	Electric fence mobile supplies	$1,274	$1,274
Spring 2022	1330	ft	Black water line	$0	$652
Spring 2022	1	each	Trenching for permanent water line	$335	$335
Spring 2022	200	ft	Flexible Hose and freight	$2	$364
Spring 2022	1	Misc.	Miscellaneous – e.g., fittings, experimental auto gates, ear tags	$324	$324
			Total Startup Costs		**$ 16,818**

Table A2: Recurring Costs and Revenues for First Grazing Event (3/24 - 5/8/2022)

Qty	Unit	Description	Unit price	Sum
20	acres	Rent	$25	$500
5	month	Electricity	$55	$275
20	acres	Oct '21 CS Cover Seed	$30	$600
20	acres	Oct '21 Drill CS Cover	$30	$600
1	Season (Cool)	Misc Expenses (labels, sweet feed)	$88	$88
3	days	Hired labor	$100	$300
10	bags	CCSseed (sown in front of cattle) Mar-May	$50	$500
		Fertilizer		$-
		Pesticide		$-
	Total Expenses			$2,863
	Income			
1694	lbs	Weight gain share 1.85 lbs.per stocker per day	$0.675	$1,143
912	Animal Days	Rent 1$/head/day ($16 * 57 days)	$1	$912
	Total Income			$2,055
	Gross margin			**-$808**

Table A3: Recurring Costs and Revenues for Second Grazing Event (7/6 - 10/3/2022)

Qty	Unit	Description	Unit price	Sum
20	acres	Rent	$25	$500
6	month	Electricity - May - Oct	$55	$330
6	bags	Millet - 8 acres West Paddock	$67	$402
3	Hr	May '22 - JD 1050 - spread Millet 8 acre	$50	$150
1	Season (warm)	Misc Expenses (well repair, sweet feed)	$60	$60
12	acres	May '22- Drill WS cover	$30	$360
12	acres	WS Cover Seed	$50	$600
3	Hrs	JD 1050 + 5' BHg, cutting lanes into forage	$50	$150
10	Hrs	JD 3080 + 10' BHg -stalk cutting pre-planting CS Cover	$75	$750
0		Fertilizer		$0
0		Pesticide		$0
	Total Expenses			$3,302
1040	lbs	Weight gain share 1	$0.725	$754
2616	Animal Days	Rent 1$/head/day for 2616 animal days	$1	$2,616
	Total Income			$3,370
	Gross margin			**$68**

Appendix 3: Pasture Lease – Contract Grazing Agreement[18]

This form was prepared to assist in reaching and recording a lease agreement. Assurance that specific legal requirements are met may require the services of a lawyer.

1. Parties: The following agreement is hereby entered into by _____, Pasture Provider, and _____, Livestock Owner, for the period of _____, 20_____ through _____, 20_____.

2. Land Description: The pasture consists of 20 acres on the Carter Farm, described as follows: Farm number 2255, Tract Number 9676 in Richland County, State of South Carolina.

3. Computation of Charges, Payment Dates:
The livestock owner will pay $1.00 per animal per day for *up to* 90 days (until 6/21/2022[19]), if both parties agree the livestock can stay on longer, this agreement can be reviewed and updated.
In addition, the livestock owner will share in 50% per live lb *gained* based on weigh-in on the day that the animals commence grazing and the day they are moved from the grazing. The price will be determined by the Market Insider (see url below[20])price on the day the livestock are removed from the land and weighed.
An example calculation is shown in Appendix 1.

4. Duties of the Livestock Owner:

a. To deliver stockers on agreed upon date and to remove stockers, pay trucking fees.
b. To pay all trucking fees associated with this pasture agreement.
c. Not to contract pasture livestock known to be unhealthy. Any stocker appearing to be diseased or in an unhealthy condition may be refused by the pasture provider.
d. Ensure positive means of livestock identification either by double tagging or by some means of permanent identification.
e. Necessary veterinary costs will be paid by the livestock owner.
f. Assist with loading and unloading of stockers.

5. Duties of the Pasture Provider

a. To place the perimeter fences and necessary cross fences in serviceable condition prior to the date livestock are brought to pasture.
b. To inspect and maintain all fences.
c. To provide a continuous supply of quality forage, primarily through timely rotation of livestock where residence time will be 4 days or less.
d. To provide an adequate source of water and availability of free-choice salt and minerals throughout the grazing season.
e. A conscientious effort will be made to pasture healthy livestock on pastures located in the Section 2 description in this agreement.
g. To notify the owner of any unhealthy or injured stockers. A joint decision will be subsequently made to contact a veterinarian when necessary.
h. Provide labor for repair of fences.
i. Return stray stockers to pasture.
k. Assist animal owner with unloading and loading of cattle.

6. Right of Entry: Both parties, and agents or employees thereof, shall have the right to enter the pasture at any time for any legitimate purpose. Gates shall be closed upon entering and leaving the premises.

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[18] Note that in this agreement, death loss was not considered, but we have been advised that this is an important component of the agreement to be included in a future contract
[19] Assuming stockers arrive at pasture on 3/23/2022
[20] https://markets.businessinsider.com/commodities/live-cattle-price

7. Arbitration: Any disagreement between the landlord and the tenant shall be referred to a board of three disinterested persons, one of whom shall be appointed by the lessor, one by the lessee, and the third by the two thus appointed. The decision of these three shall be considered binding by the parties to this lease. Any cost for such arbitration shall be shared equally by the two parties to this lease. (See Appendix 2).
8. Executed in duplicate on the date written in Item 1:

	Signature	**Date**
Pasture Provider	_____	_____
Livestock Owner	_____	_____

Witnesses:

Name	**Signature**	**Date**
_____	_____	_____
_____	_____	_____
_____	_____	_____

SAMPLE CALCULATIONS

Calculations are based on a *hypothetical* situation where 17 stockers averaging 750lb each arrive on pasture and after 90 days have gained 2 lbs/head/day. The price of beef as of the creation of this calculation (3/21/2022) is $1.41/lb of live weight according to markets Insider[21]

Based on an imaginary 17 stockers at 750 lb each and weight gained of 2 lbs/head/day gained by 17 stockers over 90 days.

Example Calculation:

Weight of livestock in = 12,750 lb and weight of livestock out = 15,560 lb, difference is 3,060 lb weight gained at price $1.41 per lb of live weight. Total value gained = 3,060 lb x $1.41 = $4,314.60 50% is $2,157.3. Therefore, if the livestock would stay the full 90 days and beef price were $1.41 on the day of the removal of the stockers, the livestock owner would pay the landowner 17 stockers x $1/day x 90 days = 1,530 rent and $2,157.3 share in weight gain = $3,687.3

[21] https://markets.businessinsider.com/commodities/live-cattle-price