Sustainable Agriculture Research; Vol. 6, No. 1; 2017
ISSN 1927-050X E-ISSN 1927-0518
Published by Canadian Center of Science and Education

Labor Use and Profitability Associated with Pasture Systems in Grass-Fed Beef Production

Basu Bhandari[1], Jeffrey Gillespie[2], & Guillermo Scaglia[3]

[1]Dept. of Agricultural Economics and Agribusiness, Louisiana State University Agricultural Center, Baton Rouge, LA, USA

[2]Animal Products and Cost of Production, Market and Trade Economics Division, USDA-Economic Research Service, Washington, DC, USA

[3]Iberia Research Station, Louisiana State University Agricultural Center, Jeanerette, LA, USA

Correspondence: Jeffrey Gillespie, Animal Products and Cost of Production, Market and Trade Economics Division, USDA-Economic Research Service, Washington, DC, USA. E-mail: Jeffrey.Gillespie@ers.usda.gov

Received: July 6, 2016 Accepted: October 28, 2016 Online Published: November 20, 2016

doi:10.5539/sar.v6n1p51 URL: http://dx.doi.org/10.5539/sar.v6n1p51

Abstract

Three pasture systems for grass-fed beef that are representative of those used in the U.S. Gulf Coast region are compared by labor use and profitability. In addition to means comparisons, stochastic efficiency with respect to a function analysis allows us to incorporate the role of risk preference in determining the most preferred production system. Five years of experimental data from the Iberia Research Station in Louisiana are used to develop revenue, expense, and labor use estimates for the three systems. Results suggest that, with or without including charges for labor, the most profitable system is the least complex bermudagrass-ryegrass system. If labor is included, a medium-complexity forage system becomes preferred for more risk averse farmers. The most complex forage system might become competitive if a carbon market were developed and/or farmers were able to realize higher grass-fed beef prices on the basis of product quality.

Keywords: grass-fed beef, stochastic efficiency with respect to a function, labor requirements

1. Introduction

Labor is a major input in livestock production. Grass-fed beef (GFB) operations are particularly labor-intensive, with labor requirements differing by production system. The major work performed by labor in a GFB beef operation includes moving, checking, and working animals, as well as operating machinery and equipment in managing forage. According to USDA-NASS (2007), most U.S. beef operations are small relative to other agricultural operations; 50% of beef farms have fewer than 20 cows and operate on a fixed land area. The GFB segment of the U.S. beef industry is similarly characterized by relatively small operations, with the labor requirements of these farms being fulfilled mostly by landowners and their family members.

Our observations suggest that a wide range of pasture management systems are used for GFB production throughout the U.S. with considerable differences in labor and management complexity. Grass-fed beef producers are expected to be interested in pasture systems that simultaneously require less labor but yield greater profit. Though GFB production accounts for a very small share of the U.S. beef industry as a whole, i.e. less than 1% of the production (Pelletier, Pirog, & Rasmussen, 2010), it has gained interest over the last two decades due to human health, environmental and animal welfare concerns (Wright, 2005; Mills, 2003; McCluskey et al., 2005).

Several studies have examined farm labor differences by agricultural production system in the beef industry. Gillespie, Wyatt, Venuto, Blouin, and Boucher (2008) analyzed the roles of labor and profitability in choosing a grazing strategy for cow-calf production in the U.S. Gulf Coast Region. They found that the greater labor requirements associated with rotational grazing systems relative to continuous grazing systems reduced the profitability associated with rotational grazing. Wyatt, Gillespie, Blouin, Venuto, Boucher, and Qushim (2013) evaluated the effects of year-round stocking rate and stocking method on cow-calf production systems considering costs, returns and labor considerations. Neither of these studies, however, have focused on GFB production. In this paper, we estimate the relative profitability of three pasture systems for GFB production with and without considering the costs associated with labor. The specific objectives of this study are to: 1) determine the operating expenses, fixed expenses, revenue, and returns over expenses of three pasture systems under GFB production; 2) determine the involvement of labor in specific activities in the three pasture systems; and 3) determine the most profitable pasture system for GFB production in the U.S. Gulf Coast Region with and without considering labor.

2. Conceptual Model

The conceptual model for this research is represented by the following profit maximizing problem for the GFB producer:

$$max\,\pi(x) = \pi(X_i) = \{\{P_{slaugh} * f(X_i) + P_{hay} * g[f(X_i)] - \sum_{i=1}^{n} W_i * X_i\} \quad (1)$$

where $\pi(.)$ is farm profit; X_i is the amount of input i; P_{slaugh} is the price of a slaughter animal; $f(X_i)$ is the production function for a GFB slaughter animal; P_{hay} is the price of hay; $g[f(X_i)]$ is the production function for hay produced in pastures, which is a function of the production of slaughter animals; and W_i is the price of input i. Here, the production function for hay from pasture is a function of slaughter animal production because the primary purpose of growing and maintaining pasture for GFB production is to produce beef, not hay. Since the primary purpose of growing forage is for grazing animals, only the left-over or excess forage is generally used to produce hay, which is in turn generally fed during periods of low grazing potential. Hay remaining after feeding animals is sold.

By solving for the first order conditions, the optimum quantity of use of input j for profit maximization can be estimated as:

$$\{P_{slaugh} * \frac{\partial f(X_i)}{\partial X_j} + P_{hay} * \frac{\partial g[f(X_i)]}{\partial X_j}\} = W_j \quad (2)$$

where the left hand side value represents the marginal value product and the right hand side represents the marginal factor cost, showing that the profit-maximizing producer determines optimal input usage by considering the marginal physical productivity, output prices, and input prices. In the case of using multiple forage species for pasture and/or hay, additional labor costs will be incurred if the additional value of the product (finished animals and hay) is greater than the additional cost associated with the labor input.

If extensive data were available, solving the profit-maximizing problem using the production function could provide the optimum level of input usage. It is often impractical, however, to collect such extensive data via experimental research, precluding the estimation of a precise optimum input-output combination based on the above conceptual model. Optimal solutions can, however, be approximated at discrete points in the production function. In this study, comparisons were made between three different pasture combinations evaluating operating expenses including labor involvement for different activities, fixed expenses, steer revenue, hay revenue, and return over expenses with each system.

3. Data and Methods

Three treatments used in a field experiment at the LSU AgCenter Iberia Research Station (IRS) in Jeanerette, LA, from 2009-2010 to 2013-2014 represented pasture systems with different degrees of management complexity. The three forage systems were: (1) bermudagrass as summer pasture, annual ryegrass as winter pasture; (2) bermudagrass as summer pasture, annual ryegrass, rye, and clover mix (berseem, red, and white clovers) as winter pastures; and (3) bermudagrass, sorghum-sudan hybrid, and forage soybean as summer pastures, and annual ryegrass, rye, clover mix (berseem, red, and white clovers), and dallisgrass as winter pastures. These systems were chosen as representative of the types of systems currently being used by GFB producers in the U.S. Gulf Coast Region (Scaglia, Rodriguez, Gillespie, Bhandari, Wang, & McMillin, 2014). System 1 consists of only two forage types and is the least complex while System 3 consists of nine forage types and is the most complex among these systems.

System 1 consists of three sub-paddocks of bermudagrass, System 2 consists of two sub-paddocks of bermudagrass, and System 3 consists of only one bermudagrass paddock. Since Systems 2 and 3 included other forages, System 1 included the greatest number of bermudagrass sub-paddocks. These sub-paddocks were divided using temporary fencing as per the availability of green forage and appropriate grazing management.

Annually, 54 seven to eight month old Fall-born steers were assigned to one of the three pasture systems immediately after weaning and remained until time of harvest at age 17-19 months. The same pastures were used for each treatment each year. The experimental year began in May and ended by the end of April the following year. The three forage systems were managed in different sub-paddocks at the IRS, and animals were rotated among the sub-paddocks based on forage availability. The steers were blocked at weaning by weight into nine groups (six steers/group). Each group was randomly assigned to one of the three treatments, each of which was replicated three times. During the transition period when forage availability was low (mid-November to December), animals were fed hay produced in the paddocks allocated to the system/replication group. Constructed portable shades were made available for the animals in each group. They were moved along with the animals when rotated. Water and mineral mix were available at all times. The stocking rate was one hectare per animal for each entire system.

Detailed expense and input records were kept for each pasture by year. These records were used to develop detailed revenue and expense estimates for each treatment/replication. These estimates included revenue, operating expenses, fixed expenses, and land rent. Expenses for seed, fertilizer, pesticides, minerals, medication, twine, fuel, purchased weaned steers, repair and maintenance of machinery, and interest on operating capital were included in the operating expenses. Depreciation and interest on machinery (trucks, tractors, and other implements), permanent fencing, and temporary fencing were included in the fixed expenses. The fixed expenses associated with machinery and equipment were allocated according to use, assuming their useful life and performance rates as shown in Boucher and Gillespie (2009, 2010, 2011, 2012, and 2013). The opportunity cost of land rental was included. Similarly, labor used for each activity was kept by pasture system. A total of 45 revenue and expense estimates were made for the project: (3 treatments × 3 replications × 5 years).

Labor usage was categorized into four subgroups. *Moving Animals and Shades* involved measuring forage availability and moving the animals among paddocks accordingly. It also included the movement of shades and water troughs. The second category was *Checking Animals and Routine Tasks*, which included checking animals twice per day Monday-Friday and once per day during the weekend. On days when the animals were moved, the checking task was conducted at the same time. Therefore, no separate labor was required for this task on the animal moving day. A third labor category was *Vaccinating Animals*. This was done as per vaccination requirements and included the labor required for working animals. The final category was *Operator Labor*, which included the labor required for operating machinery as well as labor involved in machinery, equipment, building, and fencing repair and maintenance. Much of this category involved planting and harvesting forage. Previous work examining labor use by stocking strategy includes Gillespie et al. (2008) and Wyatt et al. (2013).

The fifth year data differed somewhat from that of previous years because berseem clover, which was used in Systems 2 and 3, was not available in the local market that year. Furthermore, sorghum-sudan (System 3) was not available, but was replaced with pearl millet in the 5th year. In addition, there was a labor shortage at the IRS, so application of fertilizer and moving of animals were conducted only two-thirds of the times of the earlier years, consistently reduced across the treatments. Thus, input use differed and was somewhat lower in the fifth year. We included fifth-year data, however, since those conditions sometimes prevail in actual farm situations. Thus, it can be argued that analysis including the fifth-year data reflects the reality of resource constraints of a commercial farm.

Annual input and output prices are presented in Table 1. With the exception of those listed in subsequent discussion, these prices were those used by Boucher and Gillespie (2009, 2010, 2011, 2012, and 2013) in revenue and expense estimates for Louisiana cattle and forage production. The prices of weaned calves were obtained from 2011 Louisiana Agricultural Statistics (LSU Agricultural Center; USDA-NASS, 2012) for Years 1-3. For Years 4-5, the weaned calf price was obtained from Boucher Gillespie (2012, 2013) revenue and expense estimates due to the unavailability of Louisiana Agricultural Statistics data for those years.

Hay was measured as a large bale of average weight 430 kg. We used the Weekly Texas Hay Report for hay prices (USDA-TX, 2010, 2011, 2012, 2013, and 2014). The hay price was at its peak ($82.50 per large round bale) in 2012 due to unfavorable weather and low hay production that year. The price was approximately double that of the other years. We used the USDA-ERS (2014) published prices for fed steers as a base, adjusted for the grass-fed steer price by adding $0.44/kg as suggested by the manager of one of the larger GFB production firms in the Gulf Coast Region.

Table 1. Prices of Inputs and Outputs for the Experimental Years

Inputs/Outputs	Unit	Price in $				
		2009	2010	2011	2012	2013
Urea	Kg	0.40	0.35	0.42	0.42	0.62
Gramoxone Max	Liter	10.50	11.54	11.54	11.54	11.54
Grazon P+D	Liter	8.47	10.44	8.18	8.79	8.94
Outrider	Liter	676.28	N/A	N/A	N/A	N/A
Roundup Original Max	Liter	13.86	15.32	15.22	12.85	12.68
Malathion	Liter	N/A	8.98	8.94	8.94	N/A
Sevin 80% WP	Kg	13.51	15.01	16.20	16.20	16.20
Bovishield	Dose	2.50	2.50	2.50	2.50	2.50
One Shot	Dose	2.50	2.50	2.50	2.50	2.50
Sweetlix	Block	18.00	18.00	18.00	18.00	18.00
Ultrabac 8	Dose	0.40	0.40	0.40	0.40	0.40
Vigortone 3V2	Bag	26.20	26.20	26.20	26.20	26.20
Vigortone 3V5	Bag	17.13	17.13	17.13	17.13	17.13
Weaning Calf	CWT	98.30	114.00	114.00	125.00	150.00
Twine	Ton	0.75	0.75	0.75	0.75	0.75
Berseem Clover Seed	Kg	4.72	4.74	7.72	7.72	N/A
Red Clover Seed	Kg	5.51	6.61	2.65	2.65	3.96
White Clover Seed	Kg	5.51	7.05	6.83	6.61	6.61
Rye Seed	Kg	0.49	0.97	0.97	0.99	1.10
Ryegrass Seed	Kg	1.34	1.54	1.10	1.06	1.10
Cowpea Seed	Kg	N/A	N/A	N/A	2.20	2.20
Soybean Seed	Kg	1.23	1.17	1.32	1.32	1.32
Sorghum Sudan Seed	Kg	1.04	1.76	1.76	1.85	N/A
Pearl Millet	Kg	N/A	N/A	N/A	N/A	3.08
Hay*	Bale	45.00	40.00	82.50	37.50	40.00
Steers at Harvest*	CWT	116.00	133.00	141.00	147.00	168.00
Diesel Fuel	Liter	0.58	0.61	0.73	0.93	0.87

*Although the prices of hay and steer at harvest were tabulated as 2009, 2010, 2011, 2012, and 2013, those were based on USDA prices in the following years (2010, 2011, 2012, 2013, and 2014) since the harvesting and selling of hay and steers was in the second calendar year of the experiment.

Note: N/A indicates data not available.

Annual fixed expenses and the repair and maintenance expenses for fixed inputs are presented in Table 2. Fixed expenses of machinery and equipment were determined using the capital recovery method (Boehlje & Eidman, 1984). Annual capital recovery was calculated as:

Annual Capital Recovery Charge = {(Purchase Price - Salvage Value) * Capital Recovery Factor} + (Salvage Value * Interest Rate)

Table 2. Prices of Fixed Inputs, Machinery, and Equipment

Fixed Input Annual Costs in US$			
Input Structure	Units	Repair and Maintenance	Fixed Costs
Fence Electric	Km	23.61	156.19
Fence 5 wire	Km	130.49	302.30
hay rack	Each	9.04	26.27
Shade structure	Each	3.48	72.65
Shade cloth	Each	5.30	64.25
Water tank and pump	Each	40.00	132.50
Machinery and Equipment Costs in US$			
Machinery/Equipment		Direct Costs / Hour	Fixed Costs / Hour
Mower Conditioner		10.79	12.89
Hay Rake		2.43	3.16
Hay Tedder		2.45	3.67
Hay Fork		0.09	0.22
Baler Round		13.98	18.56
Mower Drum		4.68	5.59
Boom Sprayer		2.35	3.12
Tractor (40-59hp)		6.48	4.42
Tractor (60-89hp)		10.05	7.81
Tractor (90-115hp)		14.31	12.52

The capital recovery factor is the tabulated value based on the useful life of equipment in years and the interest rate. The fixed expense per hour was calculated by dividing the annual capital recovery charge by annual hours of use. Similarly, the operating expense per hour was estimated by computing the total repair and maintenance costs over the life of the machinery and dividing by total hours of use of the machinery.

Total Revenue and its components, Operating Expenses and its components, Return over Operating Expenses, Fixed Expenses, Total Specified Expenses, Return over Specified Expenses, and Residual Income were estimated. Residual Income is Return over Specified Expenses less land rent. Similarly, differences in the labor involved in each of the four labor categories were estimated. Differences were determined using the Kenward-Roger Degrees of Freedom method (Kenward & Roger, 1997).

Since this research is based on only 5 years of data, i.e. 45 observations, simulation and dominance techniques were used to strengthen the analysis. Simetar, a commercial mathematical simulation software developed by Richardson, Schumann, and Feldman (2008), was used to develop 1,000 randomly simulated input (fertilizer, fuel, and calves) and output (steers, hay) prices based on historical data (13 years; 2001-2013). Hay yield was estimated based on 13 years of historical rainfall data at the IRS and 1,000 randomly simulated values were developed using the same software. We did not observe significant variation in the other input variables and prices and quantities of steers, so these were taken as constant for the analysis. Based on these simulated values, 1,000 return over expense measures for each of the systems were developed.

Certainty equivalents (CE) were estimated assuming different risk preferences using the 1,000 simulated return over expenses for each system as per the relationship outlined by Hardakar, Richardson, Gudbrand, and Schuman (2004). The CE is defined as the return over expenses held with certainty at which the decision maker would be indifferent to a risky distribution of return over expense values. The utility function of the decision maker is used to estimate the CE. The relationship between the utility function $U(w)$ and the Arrow-Pratt coefficient of absolute risk aversion $r_a(w)$ (Arrow, 1971; Pratt, 1964) is shown in equation (3):

$$U(w) = -exp(-r_a(w)) \quad (3)$$

where w is return over expenses. Equation (4) defines the absolute risk aversion coefficient as the negative ratio of the second and first derivatives of the utility function:

$$r_a(w) = -\frac{u''(w)}{u'(w)} \quad (4)$$

A higher $r_a(w)$ indicates the producer is willing to accept less risk associated with return over expense, or variability of return over expense. Such an individual is more risk averse. The relationship between the coefficient of absolute risk aversion and the relative risk aversion coefficient, $r_r(w)$, is expressed as:

$$r_a(w) = r_r(w)/w \quad (5)$$

The CE for a random sample of size n from risky alternatives w is estimated as follows, as shown by Hardaker et al. (2004):

$$CE\big(w, r_a(w)\big) = ln\left\{\left(\frac{1}{n}\sum_i^n exp(-r_a(w)w_i)\right)^{-1/r_a(w)}\right\}. \quad (6)$$

A general classification of relative risk aversion coefficients falling in the range of 0 for risk neutral to 4 for highly risk averse was proposed by Anderson and Dillon (1992). Coefficients of absolute risk aversion were obtained by dividing a range of relative risk aversion coefficients (0 to 4) by the estimated mean return over expense. This yields a maximum coefficient of absolute risk aversion of 0.0024, which is used in a stochastic efficiency with respect to function analysis. Stochastic efficiency with respect to a function provides a means for evaluating the risky alternatives in terms of CEs for a specified range of coefficients of absolute risk aversion. The result is graphed to analyze which system would be preferred by GFB producers from the perspective of return over expenses and risk preference.

4. Results and Discussion

Revenue and expenses per steer excluding labor are presented in Table 3. Mean revenues from steers were \$1,434, \$1,446, and \$1,441 for Systems 1, 2, and 3, respectively, which did not differ significantly at $p \leq 0.10$ among the systems. Mean weights per steer per year were 462 kg, 461 kg, and 464 kg, respectively, for Systems 1, 2, and 3 (Table 4).

Table 3. Revenue, Expenses, and Return over Expenses (Without Labor Included), Dollars per Animal

Revenue / Expenses	System 1	System 2	System 3
Revenue			
Steers	1,434.42	1,445.68	1,440.78
Hay	667.5^{bc}	527.24^{ca}	350.91^{ab}
Total Revenue	2,109.94^{c}	1,972.93^{c}	1,791.70^{ab}
Operating Expenses			
Fertilizer	293.48^{bc}	230.44^{ca}	195.73^{ab}
Pesticides	39.47^{c}	37.67^{c}	48.02^{ab}
Livestock	690.77	690.54	692.61
Seed	55.08^{bc}	134.46^{ca}	188.34^{ab}
Twine	3.44^{bc}	2.52^{ca}	2.01^{ab}
Medication, Minerals	22.17	22.67	22.67
Diesel	68.22^{bc}	55.14^{ca}	43.27^{ab}
Repair and Maintenance Expense	59.72^{bc}	48.54^{ca}	41.10^{ab}
Interest on Operating Capital	42.72	46.68	41.82
Total Operating Expenses	1,275.68	1,264.27	1,279.27
Return over Operating Expenses	826.19^{c}	708.60^{c}	512.34^{ab}
Fixed Expenses	198.03^{bc}	158.82^{ac}	135.03^{ab}
Total Specified Expenses	1,473.73^{c}	1,423.20	1,414.42^{a}
Return over Specified Expenses	628.08^{c}	549.68^{c}	377.18^{ab}
Residual Income	545.70^{c}	457.58^{c}	305.09^{ab}

Note: Superscript a means differ significantly from System 1, superscript b means differ significantly from System 2, and superscript c means differ significantly from System 3 within rows at $p<0.10$.

Table 4. Steer Initial and Final Body Weights and Numbers of Hay Bales Produced and Fed Each Year

	Average Weight per Steer in Kg		Number of Hay Bales	
System	Initial	Final	Produced	Fed
System 1 Average	260	462	87	5
2009	255	461	54	7
2010	247	459	148	4
2011	273	466	86	6
2012	260	472	89	4
2013	266	451	59	4
System 2 Average	260	461	70	5
2009	258	445	81	7
2010	246	469	101	3
2011	275	459	58	4
2012	260	474	68	4
2013	263	460	42	5
System 3 Average	261	464	49	6
2009	256	440	64	6
2010	247	463	73	5
2011	275	474	40	5
2012	259	482	37	6
2013	266	461	29	8

Hay revenues were $668, $527, and $351 for Systems 1, 2, and 3, respectively, which differed among these systems. Hay was made from surplus green forage after grazing the animals. Of the hay produced, part of it was fed to the steers of the respective systems during the lean season of the fall when green forages were not available. Left-over hay was sold, constituting hay revenue. System 1 yielded the highest hay revenue while System 3 yielded the lowest, as more hay was harvested in System 1 than System 2 and more harvested in System 2 than in System 3. Hay produced and consumed within systems is shown in Table 4. Average hay amounts produced per system per year were 87, 70, and 49 bales in Systems 1, 2, and 3, respectively. Average hay consumption per group of 6 steers was 5, 5, and 6 bales for Systems 1, 2, and 3, respectively. Total revenues per steer per year were estimated to be $2,110, $1,973 and $1,792 for Systems 1, 2, and 3, respectively. Systems 1 and 2 had higher total revenue than System 3. The major determinant of differences in revenue by system was hay production.

Operating expenses included seed, fertilizer, pesticides, weanling animals, minerals, vaccinations, diesel, repair and maintenance, and interest on operating capital. Fertilizer expense differed among systems with the highest in System 1 and the lowest in System 3. This was due to the inclusion of leguminous nitrogen-fixing forages in Systems 2 and 3. System 3 included more leguminous forages than System 2; therefore, System 3 required less fertilizer expense than System 2. Seed expenses were greatest in System 3, which included more forage types than the other systems. Seed expense in System 1 was lowest because it included only bermudagrass and ryegrass. Similarly, diesel and repair and maintenance expenses differed among the systems because of different levels of machinery and equipment use for harvesting hay by system. Since System 1 produced more hay, machinery usage was greatest in System 1, thus greater machinery expense in System 1 than in Systems 2 and 3.

Overall, total operating expenses excluding labor were $1,276, $1,264, and $1,279 for Systems 1, 2, and 3, respectively, which did not differ statistically at $P \leq 0.10$. Return over operating expenses is total revenue less total operating costs. System 3 yielded lower return over operating expenses than Systems 1 and 2.

Fixed expenses differed among the systems due mostly to differences in the use of machinery and equipment for cutting and baling hay. Total specified expenses include both operating and fixed expenses. Return over specified expenses is estimated by subtracting total specified expenses from total revenue. System 3 yielded lower return over total specified expenses than Systems 1 and 2. Residual income was estimated after subtracting total specified expenses and an opportunity cost of land from total revenue. Residual incomes were $546, $458, and $305, respectively, for Systems 1, 2, and 3 with Systems 1 and 2 having greater residual income than System 3.

Labor involvement in the 3 systems is presented in Table 5. In total, 17, 15, and 13 hours of labor per animal were involved annually in Systems 1, 2, and 3, respectively. Greater labor involvement in System 1 was due to the greater use of machinery for harvesting and making hay, thus greater *Operator Labor*. Similarly, the movement of animals was greatest in System 1 and least in System 3, which was due to greater movement among the bermudagrass sub-paddocks (System 1) than the movement of animals between paddocks of different forage types (Systems 2 and 3). The labor involved in *Vaccinating Animals* did not differ as all systems were treated the same in this regard. Although labor involved in *Checking Animals and Routine Tasks* should generally be the same across the different systems, it differed among the systems because checking animals was conducted at the same time as moving animals on the days animals were moved. More than 50% of the total labor involved was *Operator Labor*. *Moving Animals and Shades* was the second-most labor-consuming activity, while *Vaccinating Animals* was the least labor-consuming activity.

The results of the revenue and expense analysis including labor expenses are presented in Table 6. Labor expenses are divided into operator and other labor expenses. Total labor expenses were $160, $138, and $123 for Systems 1, 2, and 3, respectively, which differed among the systems. Operator labor expenses were greatest in System 1 due to the greater use of machinery and equipment for harvesting and baling hay. Other labor expenses were also greatest in System 1 and least in System 3 due to greater movement of animals in System 1 and the least in System 3. Returns over operating expenses were $826, $709, and $512 for Systems 1, 2, and 3, respectively, without accounting for the labor costs. System 3 had lower return over operating expenses than Systems 1 and 2. The returns over operating expenses when including labor costs were reduced to $661, $564, and $385 for Systems 1, 2, and 3, respectively. Again, System 3 had lower return over operating expenses than the other systems, as shown in Table 6. Though labor used in System 1 was greater than that for the other systems, System 1 remained the most profitable of the systems.

Table 5. Annual Labor Usage Hours in the Different Systems, Hours per Animal

Labor Category	System 1	System 2	System 3
Moving Animals and Shades	4.26^{bc}	3.87^{ca}	3.42^{ab}
Checking and Routine Tasks	2.93^{c}	2.97^{c}	3.02^{ab}
Vaccinating Animals	0.37	0.37	0.37
Operator Labor	9.33^{bc}	7.35^{ac}	6.34^{ab}
Total Labor	16.89^{bc}	14.55^{ac}	13.15^{ab}

Note: Superscript a means differ significantly from System 1, superscript b means differ significantly from System 2, and superscript c means differ significantly from System 3 within rows at $p<0.10$

System 1 had greater total specified expenses than Systems 2 and 3. Return over total specified expenses was lowest in System 3 while Systems 1 and 2 did not differ statistically from each other. After accounting for labor, the residual incomes were $381, $331, and $178 for Systems 1, 2, and 3, respectively. Similar to the results without including labor expenses, the residual incomes of Systems 1 and 2 were greater than with System 3. There was no statistical difference in the residual income between Systems 1 and 2 although System 1 yielded numerically greater income than System 2.

Table 6. Revenue, Expenses, and Return over Expenses (Labor $9.60/hr. Included), Dollars per Animal

Revenue / Expenses	System 1	System 2	System 3
Revenue			
Steers	1,434.42	1,445.68	1,440.78
Hay	667.5[bc]	527.24[ca]	350.91[ab]
Total Revenue	2,109.94[c]	1,972.93[c]	1,791.70[ab]
Operating Expenses			
Fertilizer	293.48[bc]	230.44[ca]	195.73[ab]
Pesticides	39.47[c]	37.67[c]	48.02[ab]
Livestock	690.77	690.54	692.61
Seed	55.08[bc]	134.46[ca]	188.34[ab]
Twine	3.44[bc]	2.52[ca]	2.01[ab]
Medication, Minerals	22.17	22.67	22.67
Other Labor	70.57[bc]	67.21[ca]	62.29[ab]
Operator Labor	89.60[bc]	70.52[ca]	60.91[ab]
Diesel	68.22[bc]	55.14[ca]	43.27[ab]
Repair and Maintenance	59.72[bc]	48.54[ca]	41.10[ab]
Interest on Operating Capital	48.40	49.82	46.26
Total Operating Expenses	1,442.06	1,408.67	1,406.52
Return over Operating Expenses	660.51[c]	564.19[c]	385.08[ab]
Fixed Expenses	198.03[bc]	158.82[ac]	135.03[ab]
Total Specified Expenses	1,639.17[bc]	1,567.59[a]	1,541.79[a]
Return over Specified Expenses	463.04[c]	405.27[c]	249.87[ab]
Residual Income	380.70[c]	331.02[c]	177.72[ab]

Note: Superscript a means differ significantly from System 1, superscript b means differ significantly from System 2, and superscript c means differ significantly from System 3 within rows at $p<0.10$

Residual Return = Total Income - Direct Expense - Fixed Expense - Land Rent

Sensitivity analysis showed that if the wage rate for the labor were more than $32 per hour, System 2 would become numerically more profitable than System 1. In all cases, Systems 1 and 2 dominated System 3. Results of the simulation and stochastic efficiency analysis are presented in Figures 1 and 2. Figure 1 shows the stochastic efficiency with respect to a function results without including labor. It clearly shows that System 1 dominates Systems 2 and 3 at all levels of risk aversion, though the margin of dominance narrows as the coefficient of absolute risk aversion becomes larger (risk aversion increases). Revenue and expense analysis did not show that Systems 1 and 2 differed statistically; however, results of the simulation and dominance analysis clearly show that System 1 dominates both Systems 2 and 3. Furthermore, both Systems 1 and 2 dominate System 3.

The situation changes when labor is included in the profitability estimates (Figure 2). In all cases, Systems 1 and 2 dominate System 3. With coefficients of absolute risk aversion of <0.0008, System 1 dominates System 2, but for more risk averse producers where coefficients of absolute risk aversion are >0.0008, System 2 dominates System 1. Thus, the producer would make his or her decision among Systems 1 and 2 based on his/ her risk preference. There was relatively greater variability of hay production in System 1 than in System 2, thus its greater level of production risk. Since the difference in residual income without accounting for labor was wider, System 1 dominated System 2 in the former case.

5. Conclusions

Without accounting for labor, Systems 1 and 2 were more profitable than System 3. Under this condition, there is no conclusive evidence that the least complex burmudagrass and ryegrass system differs in profitability from the more complex (but not most complex) bermudagrass, ryegrass, rye, dallisgrass and clover mix (berseem, red, and white clover) system. When accounting for labor, Systems 1 and 2 were again more profitable than System 3, with no significant difference between Systems 1 and 2. Though many farm operations are run by household members, accounting for the value of labor has a significant impact on return over expenses.

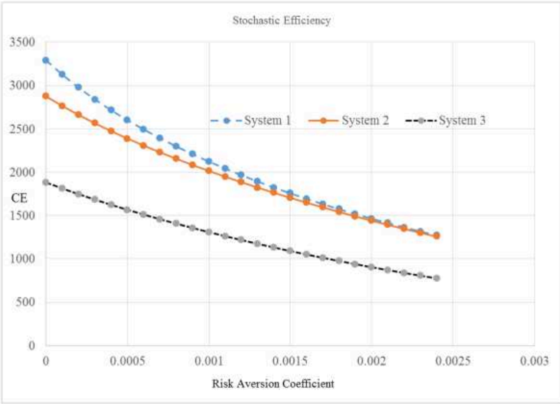

Figure 1. Stochastic Efficiency without Labor, Per Treatment (6 Animals)

System 1 was more profitable and more labor-consuming because of the greater use of machinery for hay making and harvesting. Therefore, there was less difference in the residual income among the various systems after accounting for labor. Since System 1 consists of only bermudagrass and ryegrass, it is the simplest system in the context of management complexity.

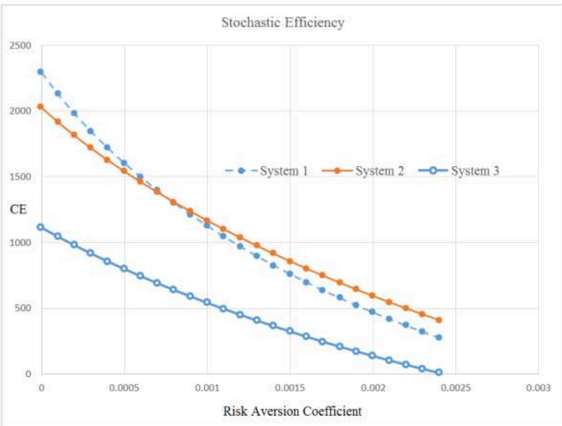

Figure 2. Stochastic Efficiency with Labor, Per Treatment (6 Animals)

On the one hand, results of simulation and stochastic efficiency analysis further confirm the results of the revenue and expense analysis. In both cases, with or without including labor inputs, Systems 1 and 2 dominate System 3. However, due to the narrower numeric difference in profitability after accounting labor, the choice between Systems 1 and 2 changes based on the risk aversion of the decision makers. The price of labor would have to be $32 or more before System 2 would become numerically more profitable holding all else equal.

If we were to consider, however, the carbon dioxide equivalent emissions from these systems, System 2 emits less than System 1 (Bhandari, Gillespie, Scaglia, Wang, & Salassi 2015). System 3 had the lowest carbon dioxide equivalent emissions. Furthermore, Torrico et al. (2014) analyzed sensory scores for the meats from the three systems and found greater sensory scores for System 3 by some groups. These results raise further concerns in determining the profitability of different systems. Further investigation on carbon emissions and the value of carbon reduction as well as the premium that could be expected for superior meat products would be needed to develop a more holistic evaluation of the economics of those systems. If reduction in carbon emissions has significant monetary value and/or farmers can receive premiums for meat that has more favorable sensory characteristics, then the more complex System 3 becomes more economically viable.

The findings of this study are useful in the context of developing a profitable GFB production program in the Southeastern U.S. Since the results are based on experimental data from a research station where conditions are more heavily controlled, there might be some variation in their wider application. Similar research can be replicated in other regions of the country to determine the appropriate pasture system by region.

Funding

This research has been funded in part by Southern SARE (LS09-211), NIFA/AFRI (2011-67023-30098), and HATCH funds (LAB 4178).

Statement

The views expressed here are not necessarily those of Economic Research Service or the U.S. Department of Agriculture.

References

Aberle, E. D., Reeves, E. S., Judge, M. D., Hunsley, R. E., & Perry, T. W. (1981), Palatability and muscle characteristics of cattle with controlled weight gain: time on a high energy diet. *Journal of Animal Science, 52*, 757-563. https:/doi.org/10.2527/jas1981.524757x

Arrow, K. J. (1971). *Essays in the theory of risk bearing*. Chicago: Markham.

Bhandari, B. D., Gillespie, J. M., Scaglia, G., Wang, J., & Salassi, M. (2015). Analysis of pasture systems to maximize the profitability and sustainability of grass-fed beef production. *Journal of Agricultural and Applied Economics, 47,* 193-212. http://search.proquest.com/docview/1718180676?pq-origsite=gscholar

Boehlje, M. D., & Eidman, V. R. (1984). *Farm Management*. New York: John Wiley and Sons.

Boucher, R. W., & Gillespie, J. M. (2009). *Projected costs and returns for beef cattle, dairy and forage crop production in Louisiana 2009*. Agricultural Economics and Agribusiness Information Series No. 263, Louisiana State University Agricultural Center, Baton Rouge, Louisiana.

Boucher, R. W., & Gillespie, J. M. (2010). *Projected costs and returns for beef cattle, dairy and forage crop production in Louisiana 2010*. Agricultural Economics and Agribusiness Information Series No. 268, Louisiana State University Agricultural Center, Baton Rouge, Louisiana.

Boucher, R. W., & Gillespie, J. M. (2011). *Projected costs and returns for beef cattle, dairy and forage crop production in Louisiana 2011*. Agricultural Economics and Agribusiness Information Series No. 274, Louisiana State University Agricultural Center, Baton Rouge, Louisiana.

Boucher R. W., & Gillespie, J. M. (2012). *Projected costs and returns for beef cattle, dairy and forage crop production in Louisiana 2012.* Agricultural Economics and Agribusiness Information Series No. 284, Louisiana State University Agricultural Center, Baton Rouge, Louisiana.

Cox, R. B., Kerth, C. R., Gentry, J. G., Prevatt, J. W., Braden, K. W., & Jones, W. R. (2006). Determining acceptance of domestic forage- or grain-finished beef by consumers from three Southeastern U.S. states. *Journal of Food Science, 71,* 2762-2771. https:/doi.org/10.1111/j.1750-3841.2006.00124.x

Fishell, V. K., Aberle, E. D., Judge, M. D., & Perry, T. W. (1985). Palatability and muscle properties of beef as influenced by pre-slaughter growth rate. *Journal of Animal Science, 61*, 151-157. https:/doi.org/10.2527/jas1985.611151x

Gerrish, J. (2006). Is pasture-finishing for you? *Beef Magazine*, 2 Oct. Available via: http://beefmagazine.com/americancowman/pasture-and-range/pasture_finished_beef/. Accessed 6 June 2011.

Gillespie, J. M., Wyatt, W., Venuto, B., Blouin, D., & Boucher, R. (2008). The role of labor and profitability in choosing a grazing strategy for beef production in the U.S. Gulf Coast Region. *Journal of Agricultural and Applied Economics, 40,* 301-313. https:/doi.org/10.1017/S1074070800028121

Gwin, L. (2009). Scaling-up sustainable livestock production: Innovation and challenges for grass-fed beef in the U.S. *Journal of Sustainable Agriculture, 33,* 189-209. https:/doi.org/10.1080/10440040802660095

Hardaker, J. B., Richardson, J. W., Gudbrand, G. L., & Schuman, K. D. (2004). Stochastic efficiency analysis with risk aversion bounds: a simplified approach. *Australian Journal of Agricultural and Resource Economics, 48,* 253-270. https:/doi.org/10.1111/j.1467-8489.2004.00239.x

Kenward, M. G., & Roger, J. H. (1997). Small sample inference for fixed effects from restricted maximum likelihood. *Biometrics, 53,* 983-997. https:/doi.org/10.2307/2533558

Louisiana State University Agricultural Center; U.S. Department of Agriculture, National Agricultural Statistics Service, Louisiana Field Office (2012). *2011 Louisiana Agricultural Statistics.* A.E.A. Information Series No. 287, Department of Agricultural Economics and Agribusiness, Louisiana State University Agricultural Center, Baton Rouge, Louisiana, October.

Oltjen, R. R., Rumsey, T. S., Puttnam, P. A. (1971). All-forage diets for finishing beef cattle. *Journal of Animal Science, 32,* 327-333. https:/doi.org/10.2527/jas1971.322327x

Pelletier, N., Pirog, R., & Rasmussen, R. (2010). Comparative 413 life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States. *Agricultural Systems, 13,* 380-389. https:/doi.org/10.1016/j.agsy.2010.03.009

Pratt, J. (1964). Risk aversion in the small and large. *Econometrica, 32,* 122-136. https:/doi.org/10.2307/1913738

Prevatt, J. W., Kerth, C. R., & Fields, D. (2006). *Marketing Alabama-grown, Forage-fed Beef.* Alabama Agricultural Experiment Station Serial Report No. 4, Auburn, Alabama.

Richardson, J. W., Schumann, K. D., & Feldman, P. A. (2008) *Simetar: Simulation and Econometrics to Analyze Risk.* Simetar, Inc., College Station, Texas.

Scaglia, G., Rodriquez, J., Gillespie, J., Bhandari, B., Wang, J. J., & McMillin, K. W. (2014). Year-round forage systems for forage-fed beef production in the Gulf Coast. *Journal of Animal Science, 92,* 5704-5715. https:/doi.org/10.2527/jas.2014-7838

Steinberg, E. L., & Comerford, J. W. (2009). Case study: a survey of pasture-finished beef producers in the Northern United States. *The Professional Animal Scientist, 25,* 104-108. https:/doi.org/10.15232/S1080-7446(15)30682-3

Torrico, D. D., Jirangrat, W., Scaglia, G., Malekian, F., Janes, M. E., McMillin, K. W., & Prinyawiwatkul, W. (2014). Proximate and fatty acid compositions and sensory acceptability of Hispanic consumers towards rib-eye steaks from forage-finished steers. *Journal of Food Science and Technology, 49,* 1788-1798. https:/doi.org/10.1111/ijfs.12552

Umberger, W. J., Feuz, D. M., Calkins, C. R., & Killinger, K. (2002). U.S. consumer preference and willingness-to-pay for domestic corn-fed beef versus international grass-fed beef measured through an experimental auction. *Agribusiness, 18,* 491-504. https:/doi.org/10.1002/agr.10034

USDA Economic Research Service (2014). US red meat and poultry forecasts. *Livestock, Dairy, and Poultry Outlook*/LDP-M-215/ 16 May.

USDA National Agricultural Statistical Service (2007). *Census of Agriculture: United States Summary and State Data*. Available at: http://www.agcensus.usda.gov/Publications/2007/Full_Report/ usv1.pdf. Accessed 1 Oct 2014.

USDA-Texas (2010). *Weekly Texas Hay Report*, April 9, 2010. USDA-Texas Department of Agricultural Marketing News, Amarillo, Texas.

USDA-Texas (2011). *Weekly Texas Hay Report*, April 8, 2011. USDA-Texas Department of Agricultural Marketing News, Amarillo, Texas.

USDA-Texas (2012). *Weekly Texas Hay Report*, April 6, 2012. USDA-Texas Department of Agricultural Marketing News, Amarillo, Texas.

USDA-Texas (2013). *Weekly Texas Hay Report*, April 5, 2013. USDA-Texas Department of Agricultural Marketing News, Amarillo, Texas.

USDA-Texas (2014). *Weekly Texas Hay Report*, April 4, 2014. USDA-Texas Department of Agricultural Marketing News, Amarillo, Texas.

Wyatt, W. E., Gillespie, J. M., Blouin, D. C., Venuto, B. C., Boucher, R. W., & Qushim, B. (2013). Effects of year-round stocking rate and stocking method systems on cow-calf production in the Gulf Coast Region of the U.S.: costs, returns, and labor considerations. *The Professional Animal Scientist, 29,* 10-15. https:/doi.org/10.15232/S1080-7446(15)30189-3

Young, A. W., & Kauffman, R. G. (1978). Evaluation of beef from steers fed grain, corn silage or haylage-corn silage diets. *Journal of Animal Science, 46,* 41-47. https:/doi.org/10.2527/jas1978.46141x