The Roles of Labor and Profitability in Choosing a Grazing Strategy for Beef Production in the U.S. Gulf Coast Region

Jeffrey M. Gillespie, Wayne Wyatt, Brad Venuto, David Blouin, and Robert Boucher

Comparisons are made concerning labor required and profitability associated with continuous grazing at three stocking rates and rotational grazing at a high stocking rate in the U.S. Gulf Coast region. A unique data set was collected using a time and motion study method to determine labor requirements. Profits are lowest for low stocking rate–continuous grazing and high stocking rate–rotational grazing. Total labor and labor in three specific categories are greater on per acre and/or per cow bases with rotational-grazing than with continuous-grazing strategies. These results help to explain relatively low adoption rates of rotational grazing in the region.

Key Words: labor requirements, rotational grazing, stocking rate, time and motion study

JEL Classifications: Q12, Q24

Rotational stocking (grazing) of pastures has been promoted by a number of groups, including governmental agencies, as having natural environment advantages over continuous stocking (grazing) at similar stocking rates. In cases where continuous grazing is chosen over rotational grazing, lower stocking rates (animals per acre) generally have conservation benefits, as overgrazing and, hence erosion, is less likely to result. Though rotational grazing or continuous grazing at lower stocking rates may be preferred from an environmental perspective, these practices are not routinely used by all cattle producers, raising the questions the following questions: (1) Are they profitable for cattle producers in the short run? (2) How do they affect management and labor requirements?

The major advantages of rotational grazing, as listed by Louisiana State University (LSU) Agricultural Center Publication 2884, are (1) increased management control and the opportunity to harvest excess forage, (2) increased efficiency of forage harvest, allowing for higher stocking rates, (3) allowance for forages to "rest and regrow" and for areas of high concentration to "heal," and (4) increased meat harvest per acre. Disadvantages, as listed by the LSU Agricultural Center, include (1) initial capital and labor expenditures as stocking rate increases, (2) greater investment risk, (3) increased management, (4) a decline in forage quality if pastures are not

Jeffrey Gillespie and Robert Boucher are Martin D. Woodin Endowed Professor and research associate, respectively, Department of Agricultural Economics and Agribusiness, Louisiana State University Agricultural Center, Baton Rouge, LA. Wayne Wyatt is professor, Iberia Research Station, Louisiana State University Agricultural Center, Jeanerette, LA. Brad Venuto is research agronomist, U.S. Department of Agriculture, Agricultural Research Service, El Reno, OK. David Blouin is professor, Department of Experimental Statistics, Louisiana State University, Baton Rouge, LA.

harvested within a certain time frame, and (5) potential reduced animal performance. Though there are numerous rotational grazing systems, rotational grazing as studied in this analysis generally includes 5 to 10 fenced paddocks that are grazed for a time period and then rested until other paddocks have been grazed, allowing forages to rest and regrow while other paddocks are grazed. The length of grazing time in each paddock depends upon forage variety, season, region, system, and other variables.

Despite significant advantages attributed to rotational grazing, only 19% of Louisiana beef producers reported using it with at least five paddocks in 2002 (Kim). In that study, nonadopters were asked whether they would accept cost-share payments of between 60% and 100% of the initial capital investment through a program such as the Environmental Quality Incentives Program (EQIP) to adopt rotational grazing. Thirty-nine percent indicated they would adopt if provided a 60% cost-share, and 60% indicated they would adopt if the federal government paid all of the initial investment costs. Though the most common reason for not adopting was that the farmer had too few animals to practically use rotational grazing (41%), the second most common reason was that the farmer preferred not to deal with the additional management and labor associated with rotational grazing (29%). Only 3% of nonadopters stated that they would not adopt because they felt rotational grazing was not profitable, while 39% of those who said they would adopt suggested they would do so because they felt it would be profitable with a cost-share (Kim). Previous unpublished surveys used by Boucher and Gillespie (1999) in determining costs of beef production suggest that stocking rates vary widely among Louisiana farmers.

Given the low adoption rate of rotational grazing in Louisiana and the apparent low interest in future adoption,[1] as well as the wide array of stocking rates used for continuous grazing, the objectives of this study were to determine, for the U.S. Gulf Coast region, differences in (1) the profitability associated with rotational grazing using a high stocking rate and continuous grazing using high, low, and medium stocking rates, and (2) labor requirements under rotational and continuous grazing. This study differs from previous grazing studies not only because it deals with grazing in a particular region, but also because it uses data collected from a detailed time and motion study to analyze the differences in a key input: labor.

Previous Literature

A substantial body of literature has amassed on the effects of stocking rate and rotational grazing on animal productivity. A relatively small subset of these studies has addressed the associated economics of these systems. This section will highlight a general lack of consensus across species regarding the benefits of rotational grazing.

A number of studies have found no differences between rotational grazing and continuous grazing at the same stocking rates in the end-of-season standing crop (Anderson; Jung, Rice, and Koong; Pitts and Bryant; Thurow). In a comparison of rotational to continuous grazing of fescue pastures at equivalent stocking rates, Chestnut et al. did not find dramatic increases in forage availability with rotational grazing. Derner et al. found that grazed heights of little bluestem were similar between continuous-grazing and eight-paddock rotational-grazing systems compared at equal stocking rates. Cassels et al., on the other hand, found an increase in forage availability with tall prairie grass with eight-paddock rotational grazing compared to continuous grazing at similar stocking rates. In terms of differences in forage quality between continuous and rotational grazing strategies, the results have varied (Aiken; Bertelson et al.; Hafley; Popp, McCaughey, and Cohen), and differences are likely attributable to factors such as stocking rates, location, trial length, and forage type.

[1] As pointed out by an anonymous reviewer, differences in stocking rates among producers may reflect rational decision making due to variation in forage quality, labor availability, equity, and other factors.

Animal performance is an important aspect of grazing strategy. Most comparisons have been made with growing steers or heifers. Some studies have compared rotational and continuous grazing at different stocking rates (e.g., Aiken; Bertelson et al.; Hafley). Studies that have compared strategies at equal stocking rates have included (1) Hart et al., who concluded that steer average daily gain on coastal Bermuda grass was unaffected by strategy (continuous versus strip grazing, which is a form of short-term rotational grazing) when adjusted to equivalent grazing pressure; (2) Gillen et al., who found that stocker cattle gains per head and per acre were lower for rotational compared with continuous grazing; and (3) Bransby, Kee, and Gregory, who found no differences in average daily gain and gain per unit land area on ryegrass pastures between continuous and short-duration rotational grazing. Bransby, Kee, and Gregory did, however, find greater individual and per unit land area average daily gains for continuous grazing at lower stocking rates and for rotational grazing at higher stocking rates. Wachenheim et al. estimated a quadratic response function to determine the economically optimal stocking rate on alfalfa pasture. They found that the economically optimal stocking rate was higher than that which maximized animal performance and lower than that which maximized pasture productivity.

Several studies have compared grazing strategies under cow-calf production. Heitschmidt et al. evaluated cow-calf production on heavily and moderately stocked continuously grazed and very heavily stocked rotationally grazed pastures (16 pastures) under extensive rangeland conditions. Mean conception rates, weaned calf crops, and production per cow did not differ among grazing methods, but production per unit land area was greater for very heavily stocked rotational grazing compared with the lower-stocked continuous grazing systems. Net returns per cow and per unit land area did not differ among the grazing systems. The authors concluded that stocking rate had a greater impact on cow-calf production than did grazing method. Chestnut et al. reported no difference between continuous and rotational grazing (7 paddock) of fescue pastures at equal stocking rates for cow or calf average daily gain or calf 205-day weight. Similarly, McCann found that calf weaning weights were unaffected by grazing method, but weaning weights per unit land area of cow-calf pairs grazing Bermuda grass–fescue pastures were 36% greater for short-duration rotational-grazing compared with continuous-grazing systems at equal stocking rates.

The differences in results among previous studies are likely explained primarily by species, region, specific rotational grazing strategies used, and other factors specific to the studies that cannot be fully explored here. Differences in results across the United States, coupled with little available detailed information specific to the Gulf Coast region, make it difficult to provide guidance to Gulf Coast cow-calf producers in selecting a grazing strategy. Furthermore, previous studies have not addressed the substantial differences associated with labor among grazing strategies.

Conceptual Economic Model

The multiperiod profit-maximizing problem for the cow-calf producer is represented by Equation (1):

$$\max \pi(x) = \sum_{t=1}^{T} \pi_t(x_{it}) = \sum_{t=1}^{T} (1-\gamma)^t \left\{ \frac{1}{Y} p_{\text{cow},t} f(x_{it}) + p_{\text{calf},t}\, g[f(x_{it})] - \sum_{i=1}^{n} \omega_{it} x_{it} \right\}, \tag{1}$$

where $\pi_t(.)$ is profit at year t, T is the number of years in the planning horizon, x_{it} is the amount of input i used at time t, γ is the discount rate, Y is the useful life of the cow in years prior to culling, $p_{\text{cow},t}$ is the price of the cull cow at year t, $p_{\text{calf},t}$ is the price of the calf at year t, $f(.)$ is the production function for the cow, $g[.]$ is the production function for the calf, which is dependent upon the condition of the mother cow, and ω_{it} is the price of input i at year t. To understand how the profit-maximizing producer would determine optimum input use, first-order conditions for profit maximization associated with input j are determined:

$$\sum_{t=1}^{T}(1-\gamma)^t\left\{\frac{1}{Y}p_{\text{cow},t}\frac{\partial f(x_{it})}{\partial x_j} + p_{\text{calf},t}\frac{\partial g[f(x_{it})]}{\partial x_j}\right\} = \sum_{t=1}^{T}(1-\gamma)^t\omega_{it}, \tag{2}$$

where the left-hand-side value represents marginal value product, and the right-hand-side represents marginal factor cost, showing that the profit-maximizing producer determines input usage by considering the marginal physical productivity, price of the output, and price of the input. In the case of stocking rate in a cow-calf production system, an additional cow (and her expected calf) will be stocked if the marginal value of the additional calves associated with the additional cow plus the marginal value of the cull cow equals or exceeds the stream of additional costs associated with the cow. Likewise, in the case of rotational grazing, additional costs of inputs, including fencing, labor, and feeding and watering equipment, will be incurred if the additional value of the product (calves) is greater than the additional costs associated with the capital and labor inputs. This model could provide information on optimal input usage if an extensive data set were available for estimating a suitably flexible production function.

In practice, data are rarely available for estimation of suitable flexible production functions in specific locations, especially if experimental data are used. In this study, a production function is not estimated due to data limitations, and, thus, profit-maximizing input levels cannot be determined. Only three stocking rates were considered in this study, providing little basis to assume a production functional form for estimating the influences of other stocking rates. Data collected in this study do, however, allow for comparisons of costs and returns among three stocking rates on continuously stocked pastures and between continuous and rotational grazing at a high stocking rate. The analysis can determine the marginal value product and marginal factor cost associated with stocking a fixed number of additional cows on pasture and, using partial budgeting, determine the impact on profit by increased stocking rate or by a change in grazing method. Thus, while this type of study cannot determine a precise profit-maximizing stocking rate and grazing strategy with a continuous function, they can be approximated by examining several discrete levels.

Methods

This study was designed as an economic and biological experiment at the Iberia Research Station in Jeanerette, Louisiana. Four stocking rate–grazing management treatments were used in this study. Treatments were randomized to pastures by field with repeated measures by pasture over years 1999, 2000, and 2001. For field 1, 16 acre pasture groups were used, while in field 2, 10 acre pasture groups were used. The sizes of pastures in this study are likely to be smaller than the average pasture size. In 2005, with 14,500 cattle producers and 860,000 cattle and calves in inventory in Louisiana (USDA–NASS), the average herd size was 59 head, which would require substantially more than 16 acres. Thus, fixed costs and some variable costs, such as labor, may be higher than would be expected for a larger operation. It is expected, however, that the median and modal herd sizes would be substantially lower than 59 head.

The four treatments were low stocking rate–continuous grazing (CL) with 0.5 cows per acre, medium stocking rate–continuous grazing (CM) with 0.8 cows per acre, high stocking rate–continuous grazing (CH) with 1.1 cows per acre, and high stocking rate–eight-paddock rotational-grazing system (RH) with 1.1 cows per acre. The design allowed the researchers to characterize the effects of stocking rate in continuously stocked pastures and to compare continuous and rotational grazing at the high stocking rate. Stocking rates were determined based upon results of unpublished surveys of Louisiana beef producers used in annual beef costs and returns estimates (Boucher and Gillespie, 1999).

The stocking rate for RH was relatively high compared with the stocking rate used by most producers for continuous grazing, consistent with rotational grazing requiring a more intensive use of the land resource for it to have potential for economic viability. The relatively heavily stocked CH treatment was included as a consistent basis for comparison. The forage grazed was a mixed warm-season perennial grass sod, primarily common Bermuda grass and Dallis grass, with an encroachment of warm-season annuals such as broadleaf signal grass and crabgrass, and weeds such as horsenettle, jungle rice, and umbrella sedge. Dormant warm-season grass pastures were overseeded with annual ryegrass each fall. The experiment was located on principally Baldwin and Iberia silty clay loam soils, which had been previously shaped to improve drainage.

Mature, spring-calving, straight-bred Brangus cows and their suckling calves were stocked onto treatment pastures year-round (for three years) beginning in February 1999. The same pastures were used for each treatment all three years; thus, the cows were not moved during the three-year trial unless they were culled. Cows were weighed and scored for body condition, and calves were weighed in late April or early May (prebreeding for cows) and again in late July (postbreeding for cows). Forage mass was determined monthly by clipping five 10 m^2 areas to ground level in each pasture. Simulated bite samples (four samples per pasture) were obtained twice monthly to determine diet quality. Depending on forage growth rate, these samples were obtained in RH pastures one to two days following rotation. This procedure was adopted in the RH pastures in an attempt to reflect average diet quality. At times when forage availability became low, cows and their calves were moved to a drylot and fed hay, protein, and mineral supplement.[2] Constructed portable shades were available for the cows in each pasture; they were moved along with the cows and calves in the RH pastures.

Detailed costs and input records were kept for each pasture by year. A field book was kept such that each time any labor activity was conducted, a description of the activity, date, time required, and number of persons conducting the activity was reported. These detailed data were the basis for the time and motion study conducted for each system. The time and motion study in this analysis, however, did not take the additional step of many time and motion studies to evaluate how efficiency can be improved within a grazing strategy; rather, labor was compared among grazing strategies. Barnes provides extensive guidance for conducting time and motion studies.

It is recognized that labor time on a state-run experiment station can differ from that of some farmers. Field staff used in this study were, however, trained extensively in conducting all required tasks. Only trained, conscientious staff who enjoyed working with cattle were allowed to work on this study. The researchers assert that if actual differences in labor time do vary between staff and some farmers (as we are certain they do for some farmers), the relative differences among graz-

[2] Movement of cows and calves to the drylot is captured in several ways. The labor associated with moving animals is captured in the labor category, "Moving Animals and Shades." The feed expense associated with the drylot is captured with line items for hay and protein in the costs and returns. Expenses associated with moving hay into the drylot are included in the fixed expenses (prorated depreciation and interest) associated with the tractor and hay fork, as well as the variable costs of operating the tractor and hay fork, which include repairs and maintenance and diesel fuel. It is recognized that animals in a feedlot will consume more per day than if on overgrazed pasture. This practice in the present study is consistent with the producer who feeds hay and protein in a drylot when pasture forage quality is low. Least squares means show that animals in the CL, CM, CH, and RH treatments spent 14, 66, 127, and 129 d per year in the drylot. Only between the CH and RH treatments were differences not found at the 0.05 level.

Table 1. Costs and Returns Included in the Comparison of Treatments

Item	Description
Revenue	
Weanling Calf	Least squares means of 205 d weaning weights multiplied by price (see Table 3).
Cull Cow	Actual means of cow weights multiplied by price (see Table 3).
Direct Expenses	
Hay	Range among 24 pasture–year combinations: 0–2.09 tons/cow/yr; $51/ton, 1999 & 2001; $49/ton, 2000 (USDA–NASS).
Protein block, 24%	Range among 24 pasture–year combinations: 0–3.64 cwt/cow/yr; $13.60/cwt.
Mineral mix	Range among 24 pasture–year combinations: 5.56–120.00 lb/cow/yr; $0.20/lb.
Ear tag	$1.11/cow
Calf vaccinations	$9.86/cow
Cow vaccinations	$11.50/cow
Dewormer	$3.30/cow
Marketing comm.	5% marketing commission charged on all cow and calf sales.
Pasture	Cost of maintaining pasture, including fertilizer, chemicals, machinery costs; Range: $67.64–$96.71/acre.
Gasoline	For pickup truck, $1.17, $1.20, $1.43/gal for 1999, 2000, 2001, respectively.
Diesel fuel	For tractors, $0.60, $0.79, $1.17/gal for 1999, 2000, 2001, respectively.
Repairs and maint.[a]	For trucks, tractors, feeders, watering system, fencing, squeeze chute, feed bunk, hay rack.
Operator labor	Cost of all labor, priced at $7.50/hr (only in Costs and Returns with Labor)
Int. on oper. cap.	Interest on operating capital, 10%.
Fixed Expenses	
Interest[a]	Interest of 6.2% on the average investment for trucks, tractors, feeders, watering system, bulls, cows, fencing, squeeze chute, feed bunk, and hay rack.
Depreciation[a]	Straight-line depreciation for trucks, tractors, feeders, watering system, fencing, squeeze chute, feed bunk, and hay rack.

Note: Total specified expenses include all expenses, both direct and fixed, listed above.

[a] Repairs and maintenance, interest, and depreciation are calculated based on actual usage of half-ton pickup truck, 68 horsepower tractor, feeders, watering system, bulls, cows, five-strand barbed wire fencing on pasture edges and electric fencing for cross-fencing, squeeze chute, feed bunk, and hay rack. Unit costs for each input are found in Boucher and Gillespie (1999, 2000, 2001).

ing strategies would not be expected to differ greatly.

Equipment records were kept, including field operation, date, time, and equipment used. Seed, fertilizer, lime, herbicide, and insecticide use were recorded, including amount, cost, and date applied. Hay yields were recorded. Feedstuffs used and days in the drylot were recorded. All cattle purchases and sales were recorded, including the reason for removal. Cows were removed if they palpated open, failed to calve, died, or had an injury or disease. They were subsequently replaced with another cow and her suckling calf.

Two sets of costs and returns estimates were developed for each pasture each year. The first set included no charge for labor, while the second included a charge for labor at $7.50/acre, the opportunity cost for operator labor used by Boucher and Gillespie (1999, 2000, 2001). A description of costs and returns categories is included in Table 1. Cow-calf production budgets by Boucher and Gillespie for 1999–2001 were modified to reflect costs associated with each pasture. *Direct expenses* included costs associated with hay, protein block, mineral mix, ear tags, vaccinations and dewormers, marketing commission, pasture expenses, fuel, repairs and maintenance, and interest on operating capital. In the set of costs and returns estimates with labor, operator labor was included as a direct expense. *Fixed expenses* included depreciation and interest on machinery and equipment. Boucher and Gillespie's (1999, 2000, 2001) budgets were modified in the following ways: (1) replacement heifers were not kept, so there was no entry for a cull heifer as cull cows were replaced by cows with calves; (2) because of (1), a 100% calving rate was assumed, a limiting assumption that overstates income to be expected, albeit consistently across pastures by year; (3) feedstuffs were adjusted according to amounts used in the experiment for each pasture by year; and (4) field operations were adjusted to those used in the experiment for each pasture by year, in turn leading to changes in machinery use.

Calf prices were estimated for each pasture based upon calf prices during the observed years and calf weight.[3] Monthly calf prices per hundredweight reported in Louisiana auctions were available for 1999–2001 for four size classes, 300–400 lbs, 400–500 lbs, 500–600 lbs, and 600–700 lbs. Using this data, a calf-price equation was estimated with calf price as the dependent variable. The following variables were included as explanatory variables: *Steer* is a dummy variable indicating the animal is a steer (versus a heifer); *Wght* is the calf weight; *Wght2* is the calf weight squared, allowing for a quadratic relationship between weight and price; *Wtr*, *Spr*, and *Sum* are dummy variables for winter, spring, and summer, with fall as the base; *Y2000* and *Y2001* are dummy variables for years 2000 and 2001, respectively, with 1999 as the base; and *Wght00* and *Wght01* are interaction terms accounting for variations in differences between prices by weight class that can occur during the cattle cycle. The equation was estimated using ordinary least squares regression. Mean calf weights for each pasture were subsequently input into the equation to determine expected price. Input prices used in each of the costs and returns estimates were collected via annual surveys of Louisiana agricultural businesses during 1999–2001 for the annual costs and returns estimates for beef cattle (Boucher and Gillespie, 1999, 2000, 2001). Thus, input prices were allowed to vary among the three years, according to those faced in 1999–2001.

Labor was divided into six general categories, and each entry in the daily log was placed into one of the six categories. *Working Cows and Calves* involved body condition scoring and palpating cows, weighing animals, weaning calves, administering fly tags, brucellosis testing, vaccinating animals, deworming, and similar tasks. *Daily Checking and Routine Tasks* involved (1) daily checking of animals, fences, and grass height; (2) pulling calves; (3) burying animals; (4) administering medicine; and (5) placing hay bales, feed blocks, and minerals in the drylot as needed. *Forage Management* involved clipping pasture, fertilizing, planting ryegrass, and spraying pastures. *Repairs and Maintenance* involved repairing fencing and shades. *Moving Animals and Shades* involved measuring forage availability, moving animals to the drylot if there was not enough forage available, and moving animals among paddocks in the rotational grazing treatment. On farms where constructed shades are not used due to adequate natural shade in each paddock, this estimate would tend to be "high." *Total Labor* was a summation of all labor used in the operation.

Differences in labor usage, costs, returns, and net returns among treatments were determined using a mixed model with fixed treatments, random pastures within treatments, and years as fixed repeated measures effects. The Kenward-Roger Degrees of Freedom method was used.

Results

Labor usage and costs and returns estimates are shown in Table 2. Each is shown on both per acre and per cow bases. The farmer with a fixed amount of land on which to graze cattle might have greater interest in the per acre comparisons, while the farmer who can vary the land input may have a greater interest in

[3] Significant differences were found in calf weights among treatments. No significant differences, however, were found in death loss or conception rate. Body condition scores differed by stocking rate, as discussed in Wyatt et al. (2006), and the only significant difference occurred between the CM and CH treatments.

Table 2. Labor Use, Revenue, Expenses, and Returns Over Expenses

Labor Measure	Continuous Low	Continuous Medium	Continuous High	Rotational High	Continuous Low	Continuous Medium	Continuous High	Rotational High
	Per Cow				Per Acre			
Labor Usage (hr)								
Total labor	8.22^{a}	6.35^{b}	5.81^{b}	9.61^{c}	3.99^{n}	5.13^{o}	6.28^{p}	10.60^{q}
Working cows and calves	4.53^{a}	3.44^{b}	2.69^{b}	2.67^{b}	2.20^{n}	2.78^{n}	2.90^{n}	2.94^{n}
Checking and routine tasks	1.78^{a}	1.82^{a}	2.25^{a}	2.34^{a}	0.86^{n}	1.47^{no}	2.44^{op}	2.58^{p}
Forage management	1.26^{a}	0.67^{bc}	0.48^{b}	0.78^{c}	0.61^{n}	0.54^{n}	0.52^{n}	0.86^{o}
Repairs and maintenance	0.28^{a}	0.20^{a}	0.13^{a}	1.48^{b}	0.14^{n}	0.16^{n}	0.14^{n}	1.53^{o}
Moving animals and shades	0.22^{a}	0.15^{a}	0.20^{a}	2.53^{b}	0.11^{n}	0.12^{n}	0.37^{n}	2.76^{o}
Miscellaneous tasks	0.15^{a}	0.08^{a}	0.06^{a}	0.08^{a}	0.07^{n}	0.06^{n}	0.06^{n}	0.08^{n}
Revenue, Expenses, and Returns Over Expenses ($, Without Labor Included)								
Total revenue	517.95^{a}	503.72^{a}	475.36^{b}	465.87^{b}	251.58^{n}	406.97^{o}	513.95^{p}	514.14^{p}
Direct expenses	290.09^{a}	250.15^{a}	264.17^{a}	287.32^{a}	141.06^{n}	202.10^{o}	285.67^{p}	317.07^{q}
Returns over direct expenses	227.86^{ab}	253.57^{a}	211.19^{bc}	178.56^{c}	110.51^{n}	204.87^{o}	228.28^{p}	197.07^{oq}
Fixed expenses	145.65^{a}	118.58^{b}	107.57^{c}	126.65^{d}	70.75^{n}	95.80^{o}	116.33^{p}	139.74^{q}
Total specified expenses	435.74^{a}	368.73^{b}	371.74^{b}	413.97^{ab}	211.82^{n}	297.90^{o}	402.00^{p}	456.82^{q}
Returns over specified expenses	82.20^{ac}	134.99^{b}	103.63^{ab}	51.90^{c}	39.76^{n}	109.07^{o}	111.95^{o}	57.32^{n}
Expenses and Returns Over Expenses ($, Labor Priced at $7.50/hr Included)								
Direct expenses	354.73^{ac}	300.11^{b}	309.88^{ab}	362.93^{c}	172.48^{n}	242.46^{o}	335.06^{p}	400.46^{q}
Returns over direct expenses	163.21^{a}	203.61^{b}	165.49^{a}	102.94^{c}	79.10^{n}	164.50^{o}	178.89^{o}	113.68^{p}
Total specified expenses	500.39^{a}	418.69^{b}	417.44^{b}	489.59^{a}	243.24^{n}	338.26^{o}	451.39^{p}	540.20^{q}
Returns over specified expenses	17.56^{ac}	85.03^{b}	57.92^{ab}	−23.71^{c}	8.35^{n}	71.22^{o}	62.56^{o}	−26.06^{p}

Note: Least squares means within a row (and under the same subheading, i.e., "per acre" and "per cow") that have any superscript in common do not differ at the 0.05 level of significance.

the per cow comparisons. Both are included and, as expected, can lead to different conclusions as to preferred grazing strategy.

Labor Usage

Table 2 presents total labor used, as well as labor used in each of the six categories. The greatest labor requirement in working cows and calves, per cow, was with the CL strategy, at 4.53 hr per cow. Actual corral and process time was prorated by animal. Substantial effort (time) is required to corral animals into the working area. While more time is required to corral more animals, the increased time is not proportionate to the number of animals; e.g., it requires similar amounts of time (labor) to corral five animals as it does to corral 20 animals. Conversely, the CL treatment required the fewest hours per acre, at 2.20 hr per acre, as there were fewer animals to process. Differences in labor for working cows and calves among the grazing strategies on a per acre basis were not, however, significant at the 0.05 level.

Checking animals and other routine tasks did not differ among grazing strategies on a per cow basis. On a per acre basis, however, CL required less labor in this category than CH or RH, and CM had a lower requirement than RH. This is due primarily to greater drylot time at the higher stocking rates, as drylot time requires that feed be brought to the animals. Increased hours per acre for RH versus CH are attributed to the increased time required to navigate around fencing when conducting field operations.

Forage crop management labor decreased on a per cow basis with continuous grazing as stocking rate increased, decreasing from 1.26 hr with CL to 0.48 hr with CH. This is attributed to the fact that time required for field operations is allocated over more animals at the higher stocking rates. The greater forage management labor requirement with RH relative to CH is attributed to the greater effort required to navigate cross-fencing when conducting field operations. Though the time requirement per acre was numerically lower as stocking rate increased with continuous grazing, differences were not found at the 0.05 level.

Repairs and maintenance on fencing and shades decreased numerically (but not significantly at the 0.05 level) on a per cow basis with increased stocking rate under the continuous-grazing treatments, but not on a per acre basis. As expected, RH required more labor for fence and shade repair than did any of the conventional-grazing strategies, roughly a 10-fold increase per acre. This was due to the increased amount of temporary cross-fencing.

Labor used for moving animals did not differ on either a per cow or per acre basis among the continuous-grazing strategies. This is in spite of the finding that forage mass generally declined in response to increased stocking rate.[4] RH, however, required greater labor time, at 2.53 hr per cow and 2.76 hr per acre, as animals were moved to new paddocks when forage availability required it. Miscellaneous labor did not differ among any of the treatments.

Total labor was greatest with RH, at 9.61 hr per cow and 10.60 hr per acre. The second highest on a per cow basis was CL, at 8.22 hr per cow, though CL was the lowest on a per acre basis, at 3.99 hr per acre. The CM and CL treatments did not differ on per cow bases, though CH labor requirements exceeded CM requirements on a per acre basis.

To summarize, RH requires substantially greater total labor on both per cow and per acre bases. This is due primarily to the increased time requirement associated with repairs and maintenance and moving animals and shades. These costs are included in the following costs and returns analysis.

[4] "Clipping" the forage was done several times in the research trial. In the first year, forage was clipped high to control for ergot in Dallis grass. Clipping was generally not done, however, in order to conserve forage for animal consumption. Hay was not made due to the difficulty of doing so in the late winter and early spring. It would, however, be possible to produce baleage in some years.

Table 3. Cow and Calf Weights at Weaning Used in Costs and Returns Analysis

	Continuous Low		Continuous Medium		Continuous High		Rotational High	
Year and Pasture	Weight	Price	Weight	Price	Weight	Price	Weight	Price
Calves[a]								
1999, 1	583	71.94	546	74.10	509	76.70	485	78.54
1999, 2	500	77.33	514	76.31	478	79.14	448	81.73
2000, 1	555	87.27	501	91.93	474	94.61	454	96.45
2000, 2	542	88.33	509	91.23	427	99.66	454	96.70
2001, 1	536	87.33	525	88.29	460	94.77	418	99.57
2001, 2	537	87.21	502	90.48	427	98.45	421	98.45
Mean	542	84.46	516	86.79	462	91.61	446	93.04
Cows[b]								
1999, 1	1,229	32.70	1,220	32.70	1,151	32.70	1,150	32.70
1999, 2	1,309	32.70	1,240	32.70	1,111	32.70	1,055	32.70
2000, 1	1,249	36.58	1,206	36.58	1,112	36.58	1,093	36.58
2000, 2	1,284	36.58	1,260	36.58	1,113	36.58	1,088	36.58
2001, 1	1,264	40.55	1,193	40.55	1,121	40.55	1,059	40.55
2001, 2	1,319	40.55	1,237	40.55	1,146	40.55	1,096	40.55
Mean	1,276	36.61	1,226	36.61	1,126	36.61	1,090	36.61

[a] Calf weights are least squares means of adjusted 205 d weaning weights, determined using a mixed model with fixed treatments, random pastures within treatments, and years as fixed repeated measures effects.
[b] Cow weights are actual (raw) means.

Costs and Returns

Table 3 presents cow and calf weights at weaning and prices at sale. Calf prices per hundredweight were determined from Equation (3):

$$
\begin{aligned}
P_{\text{calf}} = {} & 143.7871 + 10.0423 * \mathit{Steer} \\
& (7.4424) \quad (0.5459) \\
& - 0.2094 * \mathit{Wght} + 0.0001 * \mathit{Wght2} \\
& (0.0284) \qquad (0.0000) \\
& + 2.6850 * \mathit{Wtr} + 1.3159 * \mathit{Spr} \\
& (0.9154) \qquad (0.8355) \\
& + 0.1440 * \mathit{Sum} + 23.7776 * \mathit{Y2000} \\
& (0.8470) \qquad (3.4945) \\
& + 23.7393 * \mathit{Y2001} - 0.01814 * \mathit{Wght00} \\
& (3.6408) \qquad (0.0065) \\
& - 0.02088 * \mathit{Wght01}. \\
& (0.0070)
\end{aligned}
\tag{3}
$$

Numbers in parentheses are standard errors of the estimates. Estimates for *Steer*, *Wght*, *Wght2*, *Wtr*, *Y2000*, *Y2001*, *Wght00*, and *Wght01* were significant at the 0.01 level with $R^2 = 0.890$.[5] Heteroscedasticity was detected using White's robust covariance matrix, and, hence, it is corrected for using the "hetero" command in LIMDEP (version 7). As expected, multicollinearity was detected between independent variables and their interaction terms. These variables were, however, highly statistically significant and were retained in the model.

As expected, steers commanded higher prices ($10.04 more per hundredweight), while heavier animals commanded lower prices. Also as expected, season and year resulted in different prices, and year influenced the price differential between lighter and heavier calves.

Increased stocking rate resulted in reduced availability of quality forage, which lowered

[5] Generally speaking, forage mass declined in response to increases in stocking rate in the early- and late-spring periods and also in the summer. In the early spring, rotational grazing appears to have conserved the amount of forage available for grazing relative to the CH treatment, though this does not appear to have been the case in the late-spring and summer periods (see Wyatt et al., 2005a,b,c).

cow and calf weights at weaning. Calves from the heavier stocked pastures commanded higher prices per pound. In spite of the higher prices, total revenue per cow was greater for CL and CM than for CH and RH because of the sale of heavier calves and cull cows (Table 2). On a per acre basis, however, CH and RH had the greatest associated revenues, as more volume was sold per acre.

Total direct expenses per cow without labor did not differ across treatments. When labor was included, however, total direct expenses per cow were highest for CL and RH. Direct expenses per acre differed among all treatments whether or not labor expense was included, in order from highest to lowest: RH, CH, CM, and CL, reflecting the greater concentration of animals per acre.

Returns over direct expenses per cow without labor were highest for CL and CM, and for CM when labor was included. Returns over direct expenses per cow were lowest for CH and RH without labor, and for RH when labor was included. Returns over direct expenses per acre without labor were highest for CH and lowest for CL. With labor included, returns over direct expenses per acre were highest for CM and CH.

Fixed expenses per cow were ordered, highest to lowest, CL, RH, CM, and CH. The RH treatment had greater per cow fixed expenses than CM or CH because of the increased capital investment associated with cross-fencing and the machinery effort devoted to moving animals and maintaining pastures. On a per acre basis, fixed expenses were ordered, highest to lowest, RH, CH, CM, and CL.

Total specified expenses per cow without labor were highest for CL; with labor, they were highest for CL and RH. Total specified expenses per acre were ordered, highest to lowest, RH, CH, CM, and CL, regardless of whether labor was included.

Returns over specified expenses per cow were highest for CM, with CH numerically lower, but not statistically lower, regardless of whether labor was included. The highest returns over specified expenses per acre without labor were for CM and CH (and lowest for CL and RH). With labor included, the highest returns over specified expenses were for CM and CH, followed by CL, and finally RH. Results suggest that a medium to high stocking rate with continuous grazing results in the highest profit in the Gulf Coast region.

Conclusions and Discussion

Results suggest that rotational grazing at a high stocking rate is less profitable than continuous grazing at the same or a "medium" stocking rate. Returns over total specified expenses were lower for RH than for either CH or CM. When labor costs are added to the analysis, RH becomes much more costly (and thus even less profitable), as the labor analysis based upon the time and motion study suggests that about 67% more labor is required with RH than CH on a per acre basis. This study calls into question whether, for beef producers, rotational grazing has economic advantages over continuous grazing in the Gulf Coast region.

Should farmers use rotational grazing in the Gulf Coast region? To answer this, one needs to consider (1) the universality of the results of the present study and (2) the farmer's preferences. This study was conducted under relatively controlled conditions at specific stocking rates using procedures carefully considered and determined by the researchers to be most representative of area farmers. It is possible that different results could be found by comparing rotational grazing with equal-stocking-rate continuous grazing at a different or lower common stocking rate. The advantage of rotational grazing, however, would have to be substantial, given the significant differences in expenses and labor requirements between the two. Further studies on the economics of rotational and continuous grazing compared at similar stocking rates are justified.

Forage species is also an important consideration. Typical Gulf Coast grasses such as Bahia and Bermuda are low-growing grasses, storing carbohydrate reserves in the rhizomes and stolons, while upright species, such as switchgrass and bluestem, store reserves in the stem base areas, which are easily accessible to grazing animals. Grazing these low-growing Gulf Coast grasses for extended periods is less likely to compromise forage productivity than similar grazing pressure on more upright species. Hence, rotational grazing might show greater economic benefit with other species. Labor with rotational grazing is expected to greatly exceed that of continuous grazing regardless of region or forage species. Any benefits or reduced costs that might be associated with other species or conditions would have little impact on the overall labor requirement.

The second consideration for selection of a grazing method is farmer preference. Though our study did not find rotational grazing to be as profitable as continuous grazing at the similar high stocking rate, rotational grazing is promoted as having substantial environmental benefits. This needs to be considered in the adoption decision. In addition, if the farmer does not object greatly to the substantial labor increase associated with rotational grazing and finds other aspects of it to be positive for his or her farm, then it may be the most preferred practice. Education on programs such as Environmental Quality Incentives Program (EQIP) would be particularly useful for producers with a preference for rotational grazing, particularly if society deems this to be a preferred Best Management Practice.

Further research is recommended on the cumulative effects of grazing method over longer periods (multiple years). Equations (1) and (2) suggest that longer-term impacts of higher stocking rates could emerge if cow culling rates, body condition, and pregnancy rates become negatively impacted by available nutrition. Likewise, the long-run agronomic effects, such as the impact of manure distribution as well as weed dynamics by stocking rate and grazing method would be of interest. Other studies have recognized the potential for significant long-run versus short-run impacts of stocking rate on profit (e.g., Torrell, Lyon, and Godfrey). Since it is common for cattle producers to retain cows for 10 or more years, longer-term experiments with large numbers of animals would help to determine whether the short-term differences observed between these grazing systems are consistent over time.

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