Cattle Ranching Production and Marketing Strategies under Combined Price and Weather Risks

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A procedure using linear programming and Bayesian analysis for incorporating risks associated with cattle prices and forage yields was developed for maximizing net ranch income in the Southern Plains of Texas. Risk-efficient production/marketing (buy/sell) strategies included strategies which assume normal and low cattle prices and low and normal forage production. Only one of the enterprises in the risk-efficient strategies constituted a traditional marketing approach of spring buying and fall selling.

Key words: production/marketing, risk, Bayesian analysis, cattle.

Analysis of production and marketing risk in the livestock industry has been the focus of numerous investigations. Research has been conducted on livestock production risk alone (Blake and Gray; Van Tassell, Heitschmidt, and Conner; Olson and Mikesell) and on individual production alternatives considering both production and price risks (Angirasa et al.; Van Tassell, Richardson, and Conner; Musser, Shurley, and Williams). Studies on combined production and marketing strategies under risk have considered feeding and marketing strategies for cull cows in Montana with production risk alone (Yager, Greer, and Burt). Studies also have considered retaining stocker calves for finishing in integrated production enterprises in the Texas Gulf Coast (Gebremeskel and Shumway) and feedlot feeding and hedging strategies in Iowa under marketing risk (Johnson and Boehlje). Other studies have analyzed price and production risk independently for stocker steers under range conditions (Rodriguez and Taylor). This study examines both production and marketing (timing of buying and selling) strategy alternatives for multiple ranching enterprises, considering both forage production and cattle price risks.

Stocker cattle producers typically purchase cattle in the spring and sell in the fall, while cow-calf operators produce calves in the spring and sell in the fall. This pattern results in the most rapid weight gain in cattle, when range grasses are most nutritious and producing the most biomass, but it also results in seasonal price patterns of highest cattle prices in the spring and lowest prices in the fall.

Ethridge, Nance, and Dahl indicated that substantial gains in profitability are possible by foregoing some weight gain efficiency for more favorable prices in the seasonal price movements, which are quite predictable as a function of annual prices (Nance, Dahl, and Ethridge). Annual prices are less predictable.

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The objective of this research was to develop procedures to identify maximum net ranch income from alternative production/marketing systems given the production and price risks associated with those systems. Marketing was examined in a limited context of timing cattle purchases and sales. Selection of market location, pricing alternatives, and other such marketing options was not evaluated. The analysis focuses on the production situations in the Southern Plains where climate is semiarid and variable. Most cattle production occurs on native rangeland, although the production system analyzed includes a proportion of improved pastures under dryland conditions.

Procedures

The analysis was conducted in the following sequence: A ranch resource situation was defined and a set of enterprise budgets representing enterprise alternatives were constructed. Nine outcomes for cattle prices and forage production (states of nature) were identified based on combinations of three price levels for cattle (high, low, and normal) and three forage production levels (high, low, and normal). Optimal strategies for each state of nature then were determined using a linear programming model with the assumption that the state of nature is known with certainty. These optimal solutions were used to delineate a set of management adjustments and revenue outcomes for alternative states of nature (i.e., when the price-forage yield state of nature occurred differently from that assumed as the basis for the strategy). Bayesian probabilistic outcomes were determined for the nine production/marketing strategies, and the expected net returns from each of the nine strategies were estimated. To approximate the decision options of ranchers, recourse in response to alternative states of nature was allowed at mid-year, given prior decisions. The resulting payoff matrix represents the highest realistic net return outcomes under each management strategy.

Resource Situation and Enterprises

A ranch with 830 acres of native tobosagrass (*Hilaria mutica*) and 150 acres of dryland improved permanent pasture [75 acres of bluestem (*Bothrio chola* spp.) and 75 acres of weeping lovegrass (*Evagrostis curvula*)] was used. Stocker steer, stocker heifer, and cow-calf enterprises were evaluated, grazing each on bluestem, lovegrass, and/or tobosagrass. Enterprise alternatives were considered for a range of purchase/sale dates for stockers and different calving/sale dates for a cow herd. Cow-calf production was restricted to tobosagrass range because of general unsuitability of the other grasses for year-round grazing. A total of 53 enterprise budgets exhibiting positive returns to land, equipment, management, and profit at one or more of the three cattle price levels, 47 stocker cattle budgets, and six cow-calf budgets were used (tables 1–3). Budgets reflected 1985 input cost levels and were derived from Nance, Dahl, and Ethridge and from Ethridge et al. Net returns were returns to the residual claimants of land, management, profit, and fixed equipment. To compare the two types of enterprises in the model, the capital costs of fixed livestock in the cow-calf enterprises, which do not exist with the stocker enterprises, were included in costs to make the net returns of the two types of enterprises equivalent. This approach to net returns accounts for the difference in livestock capital costs between cow-calf and stocker enterprises.

Nontraditional marketing strategies considered were: (*a*) calves born in March, weaned in October, and held on pasture to be sold the following March; (*b*) calves born in October, weaned 15 June, and sold either in June or the following October; (*c*) calves born in December, weaned in July, and sold in July or October; and (*d*) stocker buy/sell strategies of January/June, January/July, January/August, January/October, June/August, June/October, June/December, October/July, and October/October.

Cattle Price Distributions

Seasonal cattle price fluctuations for both steers and heifers indicate that higher prices are achieved in March–April and lower prices prevail in October (Ethridge et al.). Stocker steer and heifer monthly average price data were obtained from the Amarillo market [U.S. Department of Agriculture (USDA) 1970–87b] on six weight groups for 1970 through 1987, 300–400 pounds, 400–500 pounds, 500–600 pounds, 600–700 pounds, 700–800 pounds, and 800–900 pounds. The monthly price series were inflated to reflect the 1985 price level

Table 1. Summary of Stocker Steer Enterprises Analyzed

Enterprise Code[a]	Purchase					Sale					Net Return ($/head)		
	Date	Weight (lbs.)	Prices ($/cwt.)			Date	Weight (lbs.)	Prices ($/cwt.)			Prices		
			Low	Normal	High			Low	Normal	High	Low	Normal	High
BS1	1 Jan.	400	55.54	65.53	73.87	1 Oct.	729	48.55	61.16	70.78	−15.96	27.34	60.57
BS2	15 Jan.	400	55.54	65.53	73.87	1 Jul.	589	51.87	63.80	76.12	−18.26	9.23	46.09
BS3	15 Jan.	400	55.54	65.53	73.87	15 Aug.	662	50.51	62.72	73.48	−10.63	26.81	61.82
BS4	15 Jan.	400	55.54	65.53	73.87	1 Oct.	723	48.55	61.16	70.78	−14.15	33.75	65.85
BS5	1 Apr.	400	60.02	70.31	80.75	1 Oct.	670	48.39	61.86	71.54	−19.35	26.61	46.53
BS6	15 Apr.	400	60.02	70.31	80.75	1 Oct.	675	48.39	61.86	71.54	−11.17	35.67	56.28
BS7	15 Jun.	400	54.67	66.74	79.80	1 Aug.	483	53.04	67.17	82.04	−12.23	6.27	24.27
BS8	1 Oct.	400	50.41	67.09	80.92	15 Jul.	672	51.27	61.66	71.16	0.66	−3.65	−1.27
LS1	1 Jan.	400	55.54	65.53	73.87	1 Oct.	740	48.55	61.16	70.78	2.11	51.22	85.51
LS2	15 Jan.	400	55.54	65.53	73.87	1 Jul.	618	51.27	61.66	71.16	−1.27	17.08	40.82
LS3	15 Jan.	400	55.54	65.53	73.87	1 Oct.	733	48.55	61.16	70.78	8.79	57.22	91.00
LS4	1 Apr.	400	60.02	70.31	80.75	15 Oct.	698	48.39	61.86	71.54	−9.65	39.88	62.30
LS5	15 Apr.	400	60.02	70.31	80.75	15 Oct.	672	48.39	61.86	71.54	−15.39	30.81	50.90
LS6	1 Oct.	400	50.41	67.09	80.92	15 Jul.	702	51.01	61.44	69.01	12.70	11.79	3.46
LS7	15 Oct.	400	50.41	67.09	80.92	15 Jul.	692	51.27	61.66	71.16	17.52	15.59	20.13
TS1	1 Jan.	400	55.54	65.53	73.87	1 Jul.	555	51.87	63.80	76.12	−7.20	16.04	48.54
TS2	1 Jan.	400	55.54	65.53	73.87	1 Aug.	586	51.48	64.10	77.72	1.96	31.95	76.13
TS3	1 Jan.	400	55.54	65.53	73.87	1 Oct.	621	48.39	61.86	71.54	−8.10	31.35	54.56
TS4	15 Jan.	400	55.54	65.53	73.87	1 Jul.	555	51.87	63.80	76.12	−2.72	20.72	53.39
TS5	15 Jan.	400	55.54	65.53	73.87	1 Aug.	586	51.48	64.10	77.72	6.21	36.66	81.01
TS6	1 Apr.	400	60.02	70.31	80.75	1 Oct.	599	49.12	64.35	75.40	−6.45	40.48	61.73
TS7	15 Oct.	400	50.41	67.09	80.92	15 Jul.	599	51.87	63.80	76.12	19.15	16.81	29.41
TS8	15 Jan.	400	55.54	65.53	73.87	15 Jul.	570	51.87	63.80	76.12	2.84	27.87	62.22

[a] B = bluestem pasture; L = lovegrass pasture; T = tobosagrass pasture; S = steer enterprise; 1, 2, . . . , 8 = weight group and buy/sell date code.

Table 2. Summary of Stocker Heifer Enterprises Analyzed

	Purchase					Sale					Net Return ($/head)		
			Prices ($/cwt.)					Prices ($/cwt.)			Prices		
Enterprise Code[a]	Date	Weight (lbs.)	Low	Normal	High	Date	Weight (lbs.)	Low	Normal	High	Low	Normal	High
BH1	15 Jan.	400	46.64	55.27	63.55	15 Oct.	733	38.41	52.70	62.28	−50.98	15.59	49.17
BH2	1 Apr.	400	49.89	59.03	69.09	15 Oct.	700	38.41	52.70	62.28	−23.80	22.65	46.21
BH3	15 Apr.	400	49.89	59.03	69.09	15 Oct.	685	41.02	54.16	63.83	−19.58	31.09	54.44
BH4	1 Jun.	500	45.12	54.85	63.62	15 Oct.	704	38.41	52.70	62.28	−50.60	−1.60	19.33
BH5	1 Jun.	400	45.40	56.81	68.71	15 Dec.	639	41.46	56.37	64.49	−24.45	21.48	21.64
BH6	15 Jun.	400	45.40	56.81	68.71	15 Dec.	609	41.46	56.37	64.49	−29.73	11.96	10.19
BH7	1 Oct.	400	40.04	56.45	68.85	1 Jul.	646	44.42	55.07	63.62	0.79	−2.77	−2.22
LH1	1 Jan.	700	46.28	55.82	58.98	15 Jun.	897	45.17	54.81	61.47	−40.66	−25.67	10.39
LH2	1 Jan.	400	46.64	55.27	63.55	15 Oct.	749	38.41	52.70	62.28	−35.47	33.20	85.67
LH3	15 Jan.	400	46.64	55.27	63.55	15 Oct.	743	38.41	52.70	62.28	−29.97	38.02	72.57
LH4	1 Apr.	400	49.89	59.03	69.09	1 Oct.	688	41.02	54.16	63.83	−14.56	36.50	59.73
LH6	15 Jun.	400	45.40	56.81	68.71	15 Dec.	589	41.52	56.71	66.52	−32.67	7.68	14.24
LH7	1 Oct.	400	40.04	56.45	68.85	1 Jul.	678	44.42	55.07	63.62	14.77	14.37	17.48
TH1	1 Jan.	700	46.28	55.82	58.98	15 Jun.	836	45.17	54.81	61.47	−28.94	−19.83	12.17
TH2	15 Jan.	700	46.28	55.82	58.98	15 Jun.	836	45.17	54.81	61.47	−23.94	−14.49	17.62
TH3	15 Jan.	500	46.50	55.25	61.10	15 Oct.	729	38.41	52.70	62.28	−37.91	16.49	53.98
TH4	1 Apr.	400	49.89	59.03	69.09	1 Oct.	599	40.01	54.61	65.79	−17.42	30.69	54.36
TH5	1 Oct.	400	40.04	56.45	68.85	1 Jul.	592	44.09	55.39	65.16	15.40	9.69	12.66
TH6	15 Oct.	400	40.04	56.45	68.85	1 Jul.	584	44.09	55.39	65.16	13.77	7.49	9.93
CB1	15 Oct.	400	40.04	56.45	68.85	15 Oct.	751	38.41	52.70	62.28	−18.04	16.68	32.24
CB2	15 Oct.	400	40.04	56.45	68.85	15 Oct.	740	38.41	52.70	62.28	−17.94	15.17	29.68
CL1	15 Oct.	400	40.04	56.45	68.85	15 Oct.	729	38.41	52.70	62.28	−16.59	14.93	28.39
CL2	15 Oct.	400	40.04	56.45	68.85	15 Oct.	727	38.41	52.70	62.28	−8.17	23.04	36.32
CL3	15 Oct.	400	40.04	56.45	68.85	15 Oct.	718	38.41	52.70	62.28	1.64	18.36	30.77

[a] B = bluestem pasture; L = lovegrass pasture; T = tobosagrass pasture; CB = combined bluestem and tobosagrass pasture (CB1 rotates 1 June, CB2 rotates 15 June); CL = combined lovegrass and tobosagrass pasture (CL1 rotates 15 May, CL2 rotates 1 June, CL3 rotates 15 June); 1, 2, . . . ,7 = weight group and buy/sell date code.

using the annual index of prices received by farmers for livestock and livestock products (USDA, 1970–87a).

Using the indexed price data over the 17-year period, monthly prices in dollars per hundredweight ($/cwt.) were obtained for each cattle weight group. Normal monthly price levels were defined as those cattle prices between 90% and 110% of the historical monthly average. A probability distribution of normal, high, and low price levels then was assessed as the relative frequency with which the three different price levels occurred by weight group. High prices were obtained by averaging the indexed prices that were above 110% of the monthly average. Low prices were generated as the weighted average of the indexed price observations that fell below 90% of the monthly average.[1] The dispersion of cattle prices differed by month and weight group. The probability distributions of monthly prices by weight group and gender were numerous and varied. However, the distribution of annual cattle price levels indicated that normal cattle prices as defined occurred 53% of the time while high and low price levels occurred 27% and 20% of the time, respectively.

Forage Yield Distributions

In the absence of historical forage production data for the study area, a precipitation-yield model by Sneva and Britton was used to estimate forage production and variability. The model used a long-term average of forage production, estimated to be 3,600 pounds per acre for bluestem, 4,000 pounds per acre for lovegrass, and 1,200 pounds per acre for tobosagrass. Precipitation data collected for Post Station, Garza County, Texas from 1923 through 1984 (National Weather Service) provided the forage yield probability distribution. A precipitation index (*PI*) was obtained by dividing the precipitation amount for any given year by the long-term rainfall average, expressing the result as a percentage. The corresponding yield index (*YI*) was computed from the equation

[1] Normal, high, and low price levels were generated in this fashion for all weight groups except for one. Due to nine of 16 observations missing for the 800–900-pound heifer weight group, it was not possible to generate distributions for that group. An equation obtained by regressing historical price data of the 800–900-pound heifer weight group on those of the 700–800-pound heifer weight group was used to generate the three price levels for that group ($H6 = 8.23 + .8516 \cdot H5$, where $H6$ = price of 800–900-pound heifers and $H5$ = price of 700–800-pound heifers; $R^2 = .85$; and F-value = 2,302.72).

Table 3. Summary of Cow-Calf Enterprises Analyzed

Enterprise Code[a]	Calving Date	Sale		Sale Prices ($/cwt.)									Net Return ($/head)		
				Low			Normal			High			Prices		
		Date	Weight (lbs.)	Steer	Heifer	Cull Cow[b]	Steer	Heifer	Cull Cow[b]	Steer	Heifer	Cull Cow[b]	Low	Normal	High
TCC1	1 Mar.	1 Oct.	411	50.41	40.44	34.82	67.09	56.45	38.69	80.92	68.85	42.56	−39.02	14.18	57.49
TCC2	1 Mar.	15 Mar.	683	51.89	44.37	34.82	64.05	57.71	38.69	72.60	64.12	42.56	40.71	107.66	149.78
TCC3	1 Oct.	1 Oct.	654	48.39	41.02	34.82	61.86	54.16	38.69	71.54	63.86	42.56	−3.84	63.69	113.75
TCC4	1 Oct.	15 Jun.	478	54.67	45.40	34.82	66.74	56.81	38.69	79.80	68.71	42.56	−38.58	6.26	53.83
TCC5	15 Dec.	1 Oct.	526	49.12	40.01	34.82	64.35	54.60	38.69	75.40	65.79	42.56	−53.44	7.74	54.10
TCC6	15 Dec.	15 Jul.	406	53.59	44.24	34.82	67.21	56.49	38.69	82.11	70.13	42.56	−68.04	−25.77	20.40

[a] T = tobosagrass pasture; CC = cow-calf enterprise; 1, 2, . . . , 6 = code for calving, sale dates.
[b] Only prices for cull cows across all weights were available. Low and high prices were calculated as 90% and 110% of the average price, respectively.

Table 4. Optimal Linear Programming Solutions for All Defined Price and Forage Conditions

Price/Forage Conditions	Livestock Enterprises	Number of Head	Marketing Strategies	Annual Net Ranch Returns
Normal Price–Normal Forage				$8,333
	Cow–Calf (TCC2)	27	March calving–March calf selling	
	Stocker Steer (BS6)	32	Graze bluestem, buy 15 Apr. at 400 lbs., sell 1 Oct. at 675 lbs.	
	Stocker Heifers (BH5)	29	Graze bluestem, buy 1 Jun. at 400 lbs., sell 15 Dec. at 639 lbs.	
	Stocker Steers (LS3)	64	Graze lovegrass, buy 15 Jan. at 400 lbs., sell 1 Oct. at 733 lbs.	
Normal Price–High Forage				$13,288
	Cow–Calf (TCC2)	44	March calving–March calf selling	
	Stocker Steers (BS6)	50	Graze bluestem, buy 15 Apr. at 400 lbs., sell 1 Oct. at 675 lbs.	
	Stocker Heifers (BH5)	46	Graze bluestem, buy 1 Jun. at 400 lbs., sell 15 Dec. at 639 lbs.	
	Stocker Steers (LS3)	101	Graze lovegrass, buy 15 Jan. at 400 lbs., sell 1 Oct. at 733 lbs.	
Normal Price–Low Forage				$4,603
	Cow–Calf (TCC2)	15	March calving–March calf selling	
	Stocker Steers (BS6)	18	Graze bluestem, buy 15 Apr. at 400 lbs., sell 1 Oct. at 675 lbs.	
	Stocker Heifer (BH5)	16	Graze bluestem, buy 1 Jun. at 400 lbs., sell 15 Dec. at 639 lbs.	
	Stocker Steers (LS3)	35	Graze lovegrass, buy 15 Jan. at 400 lbs., sell 1 Oct. at 733 lbs.	
High Price–Normal Forage				$15,403
	Stocker Steers (BS2)	1	Graze bluestem, buy 15 Jan. at 400 lbs., sell 1 Jul. at 589 lbs.	
	Stocker Steers (BS4)	30	Graze bluestem, buy 15 Jan. at 400 lbs., sell 1 Oct. at 723 lbs.	
	Stocker Steers (BS7)	62	Graze bluestem, buy 15 Jun. at 400 lbs., sell 1 Aug. at 483 lbs.	
	Stocker Steers (LS5)	71	Graze lovegrass, buy 15 Apr. at 400 lbs., sell 15 Oct. at 672 lbs.	
	Stocker Steers (TS5)	102	Graze tobosagrass, buy 15 Jan. at 400 lbs., sell 1 Aug. at 586 lbs.	
High Price–High Forage				$24,258
	Stocker Steers (BS2)	2	Graze bluestem, buy 15 Jan. at 400 lbs., sell 1 Jul. at 589 lbs.	
	Stocker Steers (BS4)	47	Graze bluestem, buy 15 Jan. at 400 lbs., sell 1 Oct. at 723 lbs.	
	Stocker Steers (BS7)	98	Graze bluestem, buy 15 Jun. at 400 lbs., sell 1 Aug. at 483 lbs.	
	Stocker Steers (LS5)	111	Graze lovegrass, buy 15 Apr. at 400 lbs., sell 15 Oct. at 672 lbs.	
	Stocker Steers (TS5)	161	Graze tobosagrass, buy 15 Jan. at 400 lbs., sell 1 Aug. at 586 lbs.	
High Price–Low Forage				$8,547
	Stocker Steers (BS4)	17	Graze bluestem, buy 15 Jan. at 400 lbs., sell 1 Oct. at 723 lbs.	
	Stocker Steers (BS7)	34	Graze bluestem, buy 15 Jun. at 400 lbs., sell 1 Aug. at 483 lbs.	
	Stocker Steers (LS5)	39	Graze lovegrass, buy 15 Apr. at 400 lbs., sell 15 Oct. at 672 lbs.	
	Stocker Steers (TS5)	57	Graze tobosagrass, buy 15 Jan. at 400 lbs., sell 1 Aug. at 586 lbs.	

Table 4. Continued

Price/Forage Conditions	Livestock Enterprises	Number of Head	Marketing Strategies	Annual Net Ranch Returns
Low Price–Normal Forage				$2,472
	Stocker Heifers (BH7)	29	Graze bluestem, buy 1 Oct. at 400 lbs., sell 1 Jul. at 646 lbs.	
	Stocker Steers (LS7)	72	Graze lovegrass, buy 15 Oct. at 400 lbs., sell 15 Jul. at 692 lbs.	
	Stocker Steers (TS7)	62	Graze tobosagrass, buy 15 Oct. at 400 lbs., sell 15 Jul. at 599 lbs.	
Low Price–High Forage				$3,948
	Stocker Heifers (BH7)	45	Graze bluestem, buy 1 Oct. at 400 lbs., sell 1 Jul. at 646 lbs.	
	Stocker Steers (LS7)	114	Graze lovegrass, buy 15 Oct. at 400 lbs., sell 15 Jul. at 692 lbs.	
	Stocker Steers (TS7)	100	Graze tobosagrass, buy 15 Oct. at 400 lbs., sell 15 Jul. at 599 lbs.	
Low Price–Low Forage				$1,384
	Stocker Heifers (BH7)	16	Graze bluestem, buy 1 Oct. at 400 lbs., sell 1 Jul. at 646 lbs.	
	Stocker Steers (LS7)	40	Graze lovegrass, buy 15 Oct. at 400 lbs., sell 15 Jul. at 692 lbs.	
	Stocker Steers (TS7)	35	Graze tobosagrass, buy 15 Oct. at 400 lbs., sell 15 Jul. at 599 lbs.	

$YI = -23 + 1.23PI$ (Sneva and Britton). The obtained YI was used to estimate annual bluestem, lovegrass, and tobosagrass forage production levels for the three range sites for 1923–84.[2] Three forage yield levels were used, as defined by Hamilton et al.: normal forage production occurs when annual rainfall is within 20% of the historical annual average, high grass production occurs when annual rainfall exceeds 120%, and low grass production occurs when annual precipitation is less than 80% of the historical average. The corresponding values of the YI are 25% on either side of the long-term average for normal yields; above 125% for high yields, and below 75% for low forage yields. Grass available for grazing on an annual basis was assumed to be 80% of the produced grass for the bluestem and lovegrass sites (McIlvain; McIlvain and Shoop; Shoop and McIlvain; Shoop, McIlvain, and Voight) and 60% for the tobosagrass site.

[2] This assumes that the precipitation distribution function dictates the yield distribution, that the two variables are linearly related, and that the rainfall distribution within years is constant. These assumptions, although oversimplifications, were used in the absence of more reliable information. Constant distribution of rain within year of rainfall was assumed because the yield index formula only holds for annual precipitation.

Linear Programming Models

To determine combinations of enterprises which maximize net returns to the ranch under different conditions, LP models were specified representing combinations of normal, high, and low cattle prices and normal, high, and low forage production. LP solutions provided primary information for subsequent Bayesian analysis by indicating enterprise combinations which maximize net returns if price and forage production levels are known (occur as assumed). The objective function was to maximize total net returns subject to specified constraints. Thirty-six transfer activities were included to transfer unused grass between months. The transfers were accomplished on a one-to-one (1:1) ratio with three exceptions. No lovegrass transfers occurred from April into May and no bluestem or tobosagrass was transferred into April from the previous month; animals discontinue using old grass when there is sufficient new grass growth to satisfy their needs. The other transfer restriction was that only 97% of the lovegrass (bluestem and tobosagrass) was transferred from month to month between October and April (March) (Reppert; Arnold). This translates to about a 15% loss during the winter months. All other

Table 5. Cattle Price and Forage Joint and Unconditional Probabilities

Price	Forage Yield Normal	High	Low	Unconditional (prior) Prob.
Normal	0.249[a]	0.122	0.159	0.530
High	0.127	0.062	0.081	0.270
Low	0.094	0.046	0.060	0.200
Unconditional (prior) Prob.	0.470	0.230	0.300	1.000

[a] .249 = (.47)(.53).

variations in forage quality were accounted for with differences in monthly rates of weight gain in the enterprise budgets.

The constraining resource was grass (or land) in each type of pasture. Monthly grass consumption requirements for cattle enterprises were obtained as the product of number of days in each month the units were kept and the daily grass consumption. The total grass available for grazing in any month was the sum of the quantity produced in that month and the amount transferred into that month.

Optimal solutions from the LP models indicated production strategies which would maximize net returns to the ranch under perfect knowledge of cattle price and forage yield levels (table 4). Bayesian analysis was used to determine the optimal production strategy in the presence of uncertain cattle prices and forage yields.

Bayesian Decision Analysis

Nine states of nature and strategies which assumed the existence of each state were defined from the combinations of cattle price and forage yield levels. Net returns computed for the nine different strategies under the nine states of nature and unconditional cattle price and forage yield probabilities (table 5) were used to obtain expected values of ranch net returns under alternative strategies. Joint prior probabilities for combinations of prices and forage levels were obtained by multiplying the price probability distribution by the forage yield probability distribution; this presumes independence between the two probabilities.[3]

[3] For the total U.S. cattle industry, cattle prices and forage yields may not be independent. However, forage availability in any single subregion may not have an impact on total cattle production of a much larger area.

Net returns from the optimal set of enterprises formed the diagonal elements of the payoff matrix. When a planned state of nature did not occur, a series of adjustments were made to the enterprise combinations to obtain the corresponding value of net returns for the off-diagonal elements of the payoff matrix. These adjustments are necessary to preserve the range resources if actual forage production is less than assumed. Conversely, greater than expected forage production may provide opportunity to increase stocking rates with some late year enterprises. A decision date of 1 July was selected since at that date the weather pattern would be sufficiently clear to know if forage production is different from that expected. In the event of lower forage production, the number of cattle on the ranch was decreased to accommodate the new forage situation. In those situations, added losses associated with forced sales and lower weight gains were reflected in net returns. In the event of higher forage production, the number of stocker cattle could be increased if the enterprise in the initial plan was not initiated before 1 July.[4]

The optimal strategy was defined as the strategy with the highest expected net return. The expected net return was computed as:

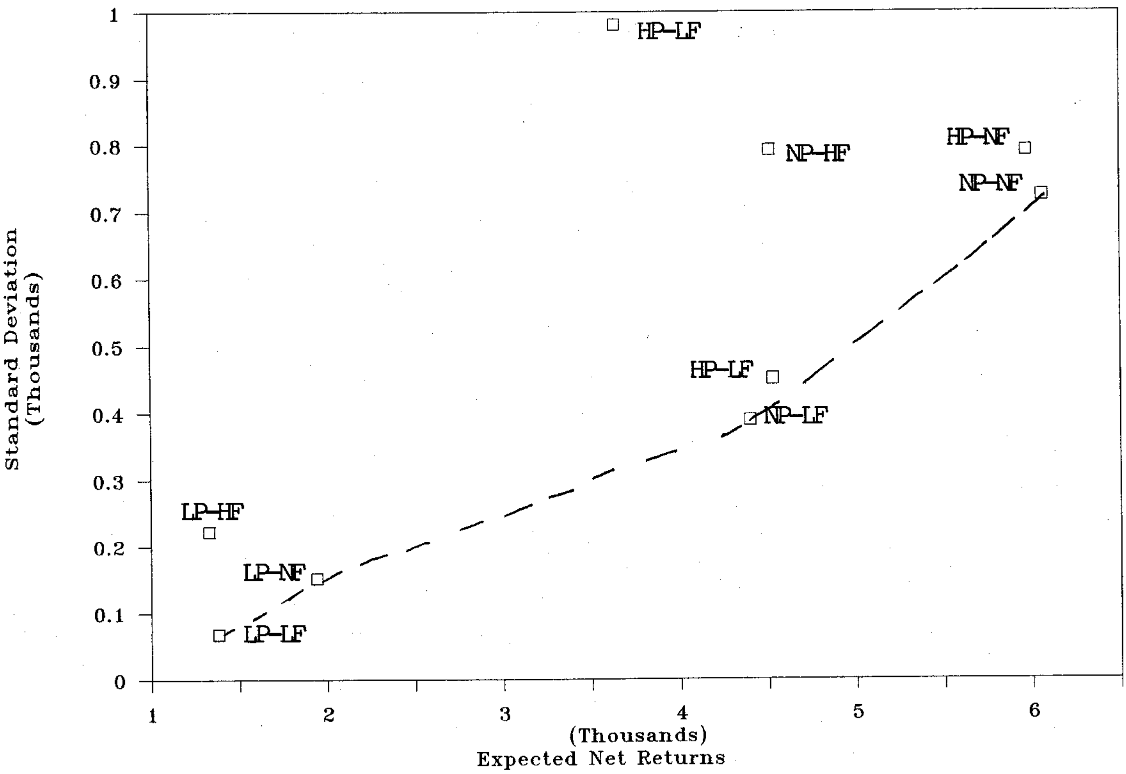
$$E(NR_j) = \sum_{i=1}^{9} P_i b_{ij},$$

where $E(NR_j)$ is the expected net return of the jth strategy; P_i is the prior probability of the ith state of nature; and b_{ij} is the value of the payoff of the jth strategy when the ith state of nature occurs (Anderson, Dillon, and Hardaker).

Results

Linear programming model optimal solutions under the varying price/forage assumptions (table 4) show how the number of animals on the ranch varies with forage production levels while the enterprise mix varies with price levels. For example, the optimal solution with known conditions of normal prices and normal

[4] The technique of discrete stochastic sequential programming would be appropriate for this problem if sufficient data were available to establish probabilities of various combinations of the states of nature for two periods of the year—before and after the 1 July decision date. In this case, data do not exist to establish forage probabilities except on an annual basis.



HP, NP, LP = high, normal, and low price strategies, respectively.
HF, NF, LF = high, normal, and low forage strategies, respectively.

Figure 1. Risk-efficient set of production/marketing strategies

forage production (NP-NF) is to have 27 cow-calf units on the tobosagrass pasture calving in March and selling yearling calves the following March, 32 400-pound stocker steers on the bluestem pasture from 15 April to 1 October, 29 400-pound stocker heifers on bluestem from 1 June to 15 December, and 64 400-pound stocker steers on lovegrass pasture from 15 January to 1 October. With known conditions of high cattle prices and normal forage production, the optimal production/marketing mix shifts to stocker steer enterprises with conventional marketing strategy (spring purchase, fall sale) only on the lovegrass pasture. Under known low cattle prices, both steers and heifers enter the solution without any conventional marketing.

Optimal Strategy

A payoff matrix and expected values and net returns were obtained for each strategy using the unconditional probability distribution of the cattle price-forage yield distribution (table 6). The normal price-normal forage (NP-NF) strategy resulted in the highest expected value of ranch net returns, followed closely by the high price-normal forage (HP-NF) strategy. All low price strategies resulted in lower expected net returns than normal and high price strategies. Risk was considered for all strategies by comparing their standard deviations. The risk-efficient set of production/marketing strategies is illustrated in figure 1. Based on expected income and variance considerations, strategies NP-NF, NP-LF, LP-LF, and LP-NF dominated the others. The strategies associated with high price and/or high forage assumptions were too risky to be in the efficient set of strategies. The risk-efficient set of strategies encompassed seven enterprises (TCC2, TS7, BS6, BH5, BH7, LS3, and LS7), only one of them being a traditional marketing pattern of spring buying or calving and fall selling.

Table 6. Ranch Net Returns, by Strategy and State of Nature

	States of Nature									Net Returns	
Strategies[a]	NP-NF	NP-HF	NP-LF	HP-NF	HP-HF	HP-LF	LP-NF	LP-HF	LP-LF	Expected	Standard Deviation
	$/strategy										
NP-NF	8,333	8,698	1,852	12,297	12,664	5,183	595	180	−3,373	6,059	724
NP-HF	4,893	13,288	−1,877	10,400	19,591	3,521	−4,136	996	−8,414	4,514	792
NP-LF	4,483	5,248	4,603	7,072	7,440	6,791	8	−407	326	4,399	389
HP-NF	7,337	7,563	1,150	15,403	16,277	7,797	−1,660	−2,101	−5,082	5,972	791
HP-HF	3,716	11,541	−4,973	14,373	24,258	3,502	−6,949	−2,609	−12,375	3,640	981
HP-LF	4,254	4,479	4,078	9,227	10,101	8,547	−1,087	−1,327	−903	4,527	450
LP-NF	2,084	2,084	413	3,208	3,208	626	2,472	2,472	1,627	1,940	151
LP-HF	1,369	3,334	−1,718	2,018	5,136	−2,236	2,326	3,948	1,000	1,328	222
LP-LF	1,168	1,168	1,168	1,799	1,799	1,799	1,384	1,384	1,384	1,381	68
Probabilities[b]	(.249)	(.122)	(.159)	(.127)	(.062)	(.081)	(.094)	(.046)	(.060)		

[a] N, H, and L stand for normal, high, and low levels, respectively. P and F stand for cattle price and forage yield levels, respectively.
[b] Numbers in parentheses are the unconditional probabilities of occurrence for the *i*th states of nature.

An alternative method which used cattle price and yield forecasts, derived as Markov chain-type transition probabilities as conditional probabilities, also was implemented. However, those forecasts produced no meaningful increase in ranch income in this instance (less than a $20 increase in annual ranch net income). That is, prior years' weather and prices were not effective predictors of current weather and prices in the study region. The Markov chain transition probabilities may provide effective forecasts in other contexts.

Conclusions

This analysis indicates that deviations from conventional cattle production and marketing approaches can increase individual ranch incomes in the Southern Plains and probably in other regions as well. That is, substitution of a degree of price enhancement through altering the production/marketing cycle for a degree of physical cattle/weight-gain efficiency increases net ranch income. However, if large numbers of producers alter their production/marketing approach, seasonal price patterns or advantages of nontraditional strategies may change. The reason(s) for discrepancies between the optimal approaches suggested by the results and conventional practices is unknown, but there are several possible explanations. The approaches suggested by model solutions may require a level of management ability which few ranch managers possess. It is also possible that most ranch managers are not motivated to achieve profit maximization in the broad context of alternatives analyzed here, but seek profit maximization only within a narrower context of conventional approaches. Alternatively, perhaps they do not consider the broader set of alternatives because they are unaware of the potential gains or lack the independent capability to analyze them.

The risk-efficient set of production/marketing strategies, considering both price and weather risks in the Southern Plains, includes strategies which assume normal and low prices and normal and low forage production. The efficient strategy for a manager preferring the lowest risk is one which assumes low prices and low forage production. The efficient strategy for the manager willing to accept high risk assumes normal prices and normal forage production. Efficient strategies for managers wanting intermediate risk assume normal prices and low forage production. The difference between the intermediate and high risk-efficient strategies is in the number of cattle in the four enterprises.

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